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PRODUCT ENGINEERING

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DESIGNING SAFETY INTO FLYING

THE TANAGER which won the Guggenheim Safe Aircraft Contest was an experimental model in which were combined a number of safety features upon which the Curtiss-Wright engineers had been working for a considerable period. The ship itself was built in order to enter the Guggenheim Competition and also to give practical flight tests of these various safety features.

Virtually all of the experimental factors in the design of the Tanager proved sound. It is our intention to apply these factors to commercial aircraft in due time. There are no short cuts in so highly scientific a matter as the design and construction of new airplanes. Many detailed difficulties must be overcome to permit even a slight change from normal design. Such radical changes as are found in the Tanager must be applied by a slow and careful process to production airplanes.

The present day airplane is adequate for the purpose which it was designed to serve—that is, operation by a pilot especially trained to fly under all conditions. To build an airplane which everyone can fly in the sense that an automobile is a vehicle which every normal person can drive, we believe that the various elements that were combined to make the Tanager the safest airplane in the world are valuable steps in the direction of this goal. But such an ambitious aim cannot possibly be accomplished in a moment. The present airplane must serve the present usages of air transportation.

The Tanager itself, was, as I have stated, an experimental ship and has no immediate commercial value as a type. But we are very optimistic concerning the ability of our engineers to apply its principles to an airplane that has commercial value.

Walter H. Beech

Vice-president in Charge of Sales, Curtiss-Wright Corporation

An AIRPLANE DESIGN to MEET SPECIFIC CONDITIONS

By ROBERT R. OSBORN

Designer, Curtiss Aeroplane & Motor Company

"Thirty years hence, it should definitely be easier to fly than to drive a car today. If not, it will be because the aircraft industry has failed to measure up to its responsibilities."

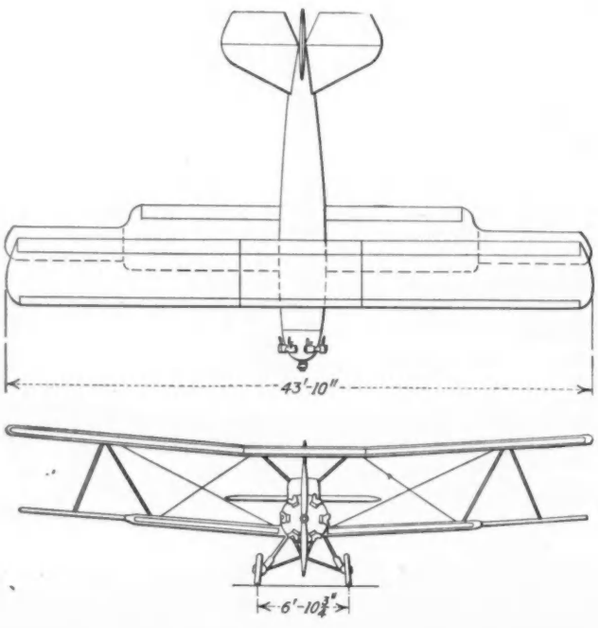
EDWARD P. WARNER, Editor of Aviation, in American Machinist A.S.M.E. Fiftieth anniversary number.

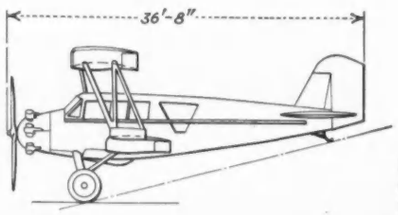
TYPES of construction that seem destined to play no small part in future aircraft development are embodied in the Tanager, an airplane designed primarily to meet the requirements of the Guggenheim competition. Although this was notably a safety competition, its rules stipulated that the planes entered should not sacrifice "the good qualities of present-day aircraft." In designing the Tanager, however, it was decided not to build a plane that merely would last through the competition, but one that, with minor changes in construction intended to facilitate manufacture at moderate cost, could be put into production if the company so elected.

In the present article it is proposed to show what factors make for safety in flying, and how the Tanager was designed to meet these factors. The Tanager is a three-place (three seat) enclosed-cabin biplane. It departs from conventional design principally in having three devices that not only promote safety but yield other benefits. One of these is a new type of floating aileron. The others are slots and flaps similar to those used by several competing planes, but having certain original features.

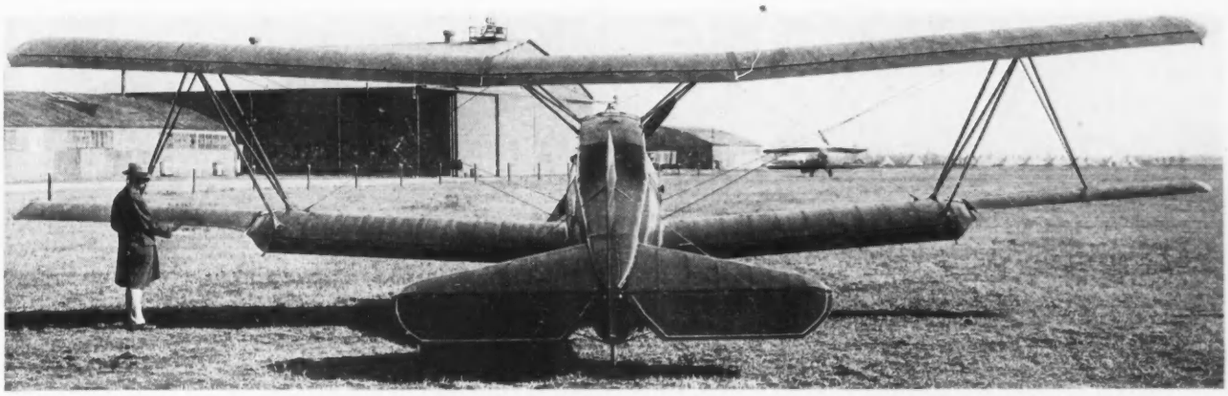
Among the most important conditions required for safety in flying, especially when the pilot is inexperienced, are that the plane should:

1. Be capable of a low landing speed
2. Be free from any tendency to fall accidentally into a spin, even though stalled in flight
3. Be capable of resisting without failure landing shocks much more severe than are encountered normally in experienced piloting
4. Be so simple to control that the pilot is not likely to become confused in an emergency with the danger of a crash in landing
5. Be capable of landing in and taking off from confined spaces surrounded by obstructions
6. Be capable of gliding without power at small angles (to reach a distant field in the event of engine failure) as well as at steep angles (to assure a safe landing upon a near-by field)
7. Be inherently capable of stability in normal flight with controls left free





PLAN and two elevations of the plane, showing major dimensions



REAR VIEW of the Tanager, showing the flaps at the rear of both wings, and the floating ailerons

8. Afford unobstructed vision for the pilot and include all reasonable provision against fire risks.

How could these conditions be met in designing the Tanager, and at the same time retain the good points of conventional heavier-than-air craft? In the answer lay not only the secret of success or failure in the competition, but a larger and far more important stake—added safety in future flying.

To secure the low landing speed of 35 m.p.h. required, it was necessary to have a moderately low wing loading, and consequently, a fairly large wing area. This was one reason for choosing a biplane. Besides, a 110 m.p.h. maximum speed also was required. This and other requirements made it necessary that the weight be kept at a minimum, and that the drag also be minimized by using efficient airfoil sections.

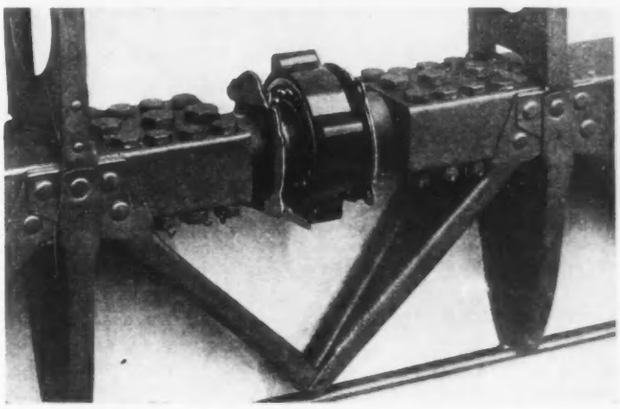
WEIGHT was reduced by using throughout the lightest materials and type of construction feasible, regardless of cost. Thus heat-treated chrome-molybdenum steel tubing of 175,000-lb. tensile strength was used in some highly stressed members, such as the landing gear. At other points where thicker sections were needed for stiffness Duralumin tubing or sheet was selected. In still other cases, especially in the wing beams and ribs, spruce was employed together with high-tensile steel fittings and cross-wires. "Doped" fabric covering was used on nearly all exposed surfaces. The landing gear is comprised of high-tensile steel, with rubber and hydraulic (oleo) shock absorbing devices. Total weight of the empty plane finally resulting was 1,959 lb., and the useful load carried was 882 lb., giving a wing loading 8.5 lb. per square foot.

Much lower landing and gliding speeds than would be possible in a conventional plane are obtainable with the Tanager by reason of its unconventional supplementary devices. Two of these increase the lift under certain conditions. The novel floating ailerons perform another and important function in maintaining the lateral control.

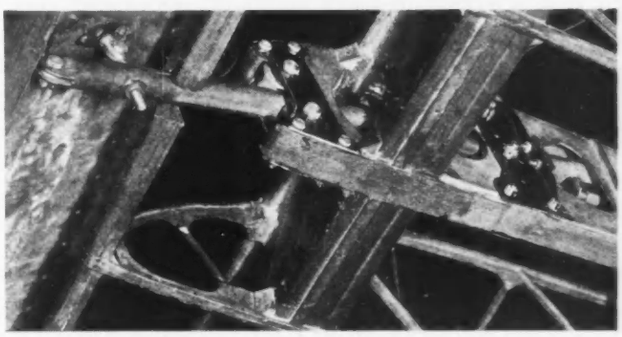
To understand the operation of the slots and the flaps some details of wing construction require consideration. An efficient wing section, the "Curtiss 72 airfoil," was employed. This section is made in three parts, of which only the main or central portion remains fixed. In normal level flight, however, all three parts may remain in fixed relative position, but the plane could be made to take off, fly and land without change in this position, although, in this case, the ship would have to be landed at a speed comparable to that of conventional planes.

At the front edge of the wing, and normally resting

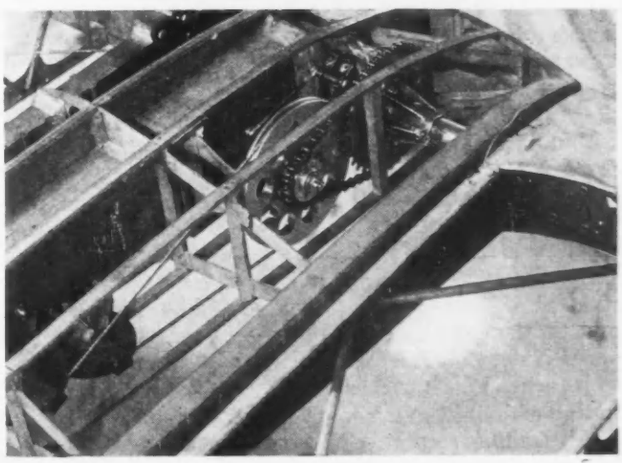
PART of the floating aileron which is mounted in self-aligning ball bearings. It is built up largely from Duralumin channel and formed sheet

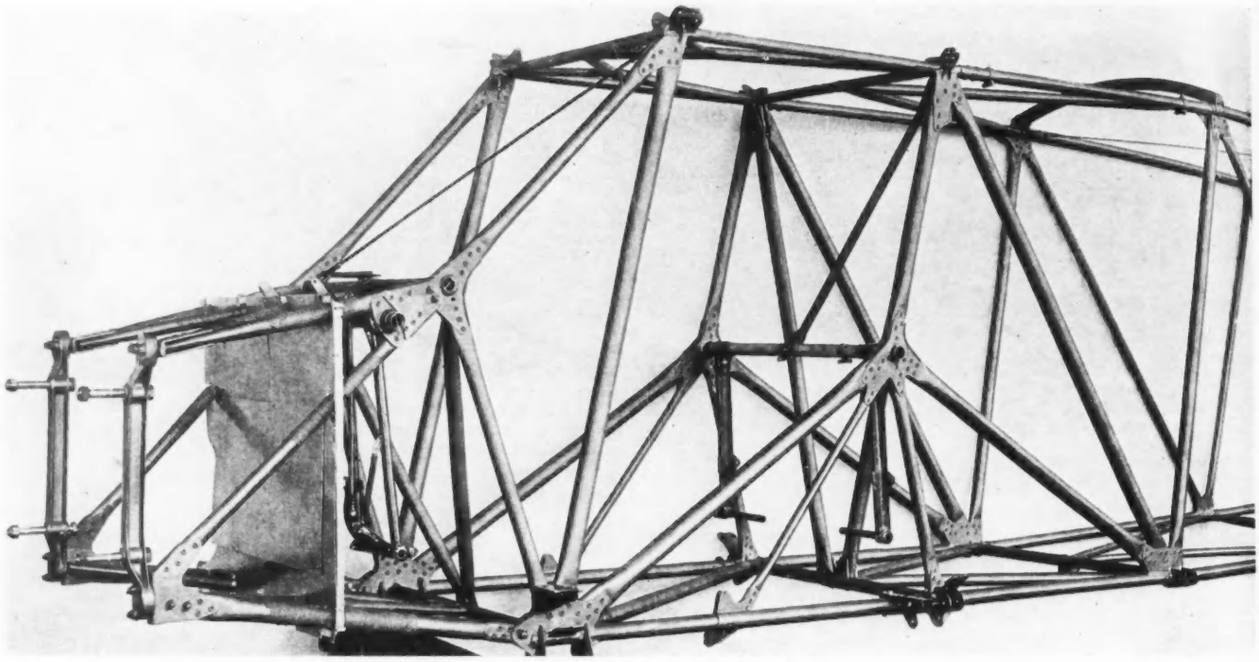


DETAIL of the wing slot mechanism, showing one of the curved tubular supports passing between two pairs of ball bearing grooved rollers



END of lower wing showing parts of the aileron control.





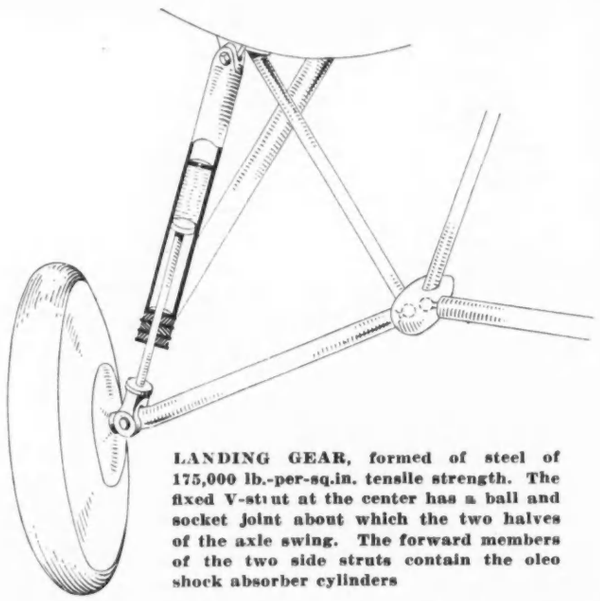
FORWARD END of the fuselage. The horizontal tubes at top and bottom are high-tensile steel with welded fittings. All other tubes are of Duralumin fastened together with tubular rivets

against the main fixed section, is a separate airfoil, supported upon tubes bent to the arc of a circle and projecting inside the main portion of the wing. Each of these tubes rests between two pairs of ball bearing grooved rollers. Movement of this airfoil is entirely automatic, its amount, and the width of the slot thus opened, being dependent upon the curvature of the tubular supports and the pressure exerted. The slot opens a variable amount, that is, until the resultant pressure is radial to the arc of the supporting tube. No fluttering occurs. The slot does not being to open until the angle between the plane of flight and the plane of air motion, equals 12 deg. Thereafter its width increases to a maximum of $6\frac{3}{4}$ in. when the angle of attack is 16 deg. The maximum lift with the slot open is secured when the angle of attack is 26 degrees.

WHEN the slot, which has a venturi section, opens, air flows upward through the slot. This changes the character of the air flow along the wing surfaces, simultaneously increasing the lift to a maximum of 50 per cent in wide open position, which is the position it occupies when the plane stalls and starts to settle in making its most abrupt landing.

About one-quarter of the wing, instead of being integral, as in the normal plane, is hinged to the center section, forming a flap the position of which can be varied with a manual control. For normal level flight the maximum speed is obtained when the flap is not deflected. In this neutral position the flap is, in effect, only the trailing section of the "72" airfoil, but when it is deflected downward the lift is increased (as much as 33 per cent for maximum deflection) and the speed of the plane is reduced. By this means the rate of take-off is increased and the landing speed is decreased, but the maximum speed is not reduced for the flap can be returned quickly to its neutral position. All of these results are very much in line with objectives sought in this design.

All trailing sections of both wings are used as flaps,



LANDING GEAR, formed of steel of 175,000 lb.-per-sq.in. tensile strength. The fixed V-strut at the center has a ball and socket joint about which the two halves of the axle swing. The forward members of the two side struts contain the oleo shock absorber cylinders

whereas, in the conventional plane, a part of this area is devoted to ailerons. A venturi slot always is open between the flap and the wing but this slot does not change the wing characteristics in the flap's neutral position. In other positions the slot adds to the effectiveness of the flap by increasing lift. The total increase in lift with flaps at maximum deflection and all slots open is 83 per cent greater than if these features were not employed. These characteristics were obtained as a result of careful design and numerous wind tunnel tests.

A still more important advantage from a safety standpoint is accomplished by the floating ailerons. In conventional planes the common ailerons are hinged to and form a part of the wing surface. Their function is to control the roll of the ship laterally about a fore-and-aft axis, but when used they tend to cause yawing, or turning in a horizontal plane about a vertical axis. To offset the latter tendency, a counteracting couple is produced by using the rudder. For any setting the conventional

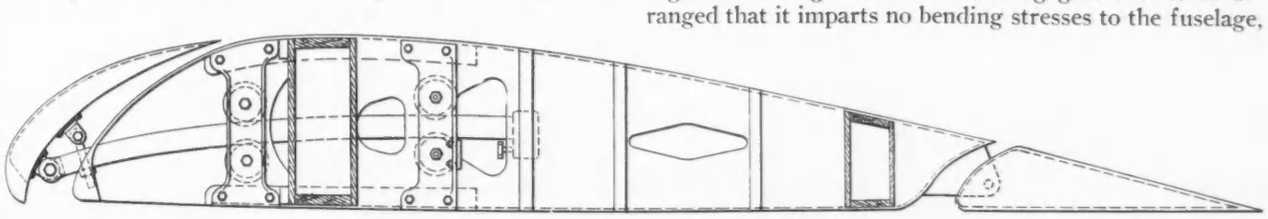
aileron moves with the wing and turns as a part of the wing when the plane changes its angle of attack.

None of these things are true with respect to the Tanager's ailerons except that they do give effective lateral control. They are not a part of the wing surface, but are carried at each end of the lower wing, being pivoted and free to rotate or "float" about an axis parallel to the wings. No matter what attitude the ship assumes, the ailerons automatically continue to hold a position parallel to the air stream. They can be diverted from this position by use of the control. This rolls the ship about its fore-and-aft-axis but does not disturb stability about any other axis. This control does not change the ailerons' position relative to the ship, but it does control their position relative to each other, deflecting one up and the other down through precisely the same angle. Since the section of the ailerons is symmetrical, and they are balanced aerodynamically and mechanically, this control produces almost no tendency to yaw because the increased drag is substantially equal at both sides and practically no turning movement is created. Consequently, no interconnection or coordination of the ailerons with the rudder is required and flying is materially simplified.

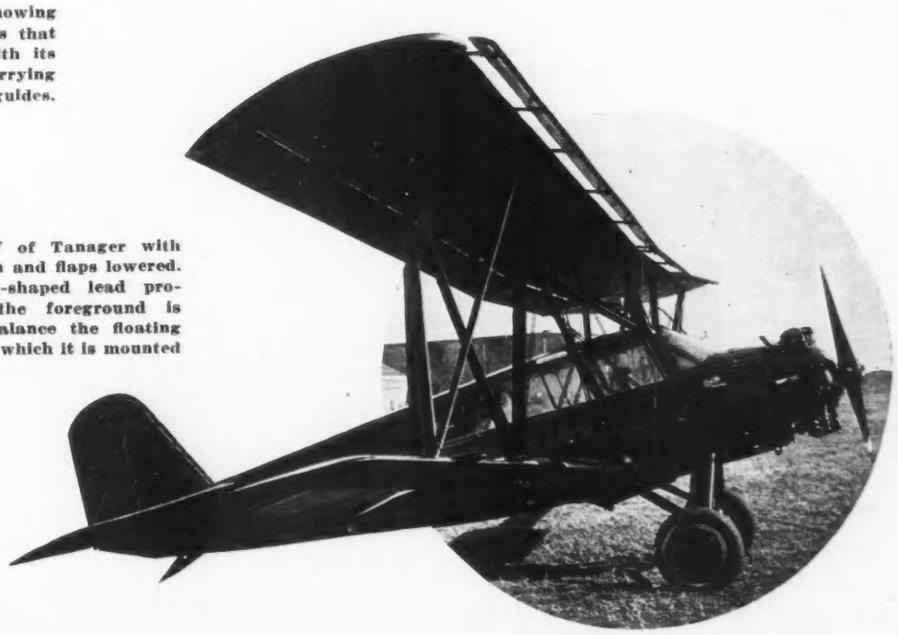
OTHER important advantages of the ailerons include their ability to produce the same rolling movement, when deflected, regardless of the angle of attack, and to give about 50 per cent more control at the stall. They do not occupy space that otherwise could be devoted to lifting surfaces or flap, hence the maximum speed is increased and the advantages of extra flap area are realized. Finally, they prevent the plane from falling into a spin even though stalled in flight. This is most important because many accidents, especially among novice fliers, result from such spins. When a conventional plane is stalled in a climbing attitude, its speed is reduced to a point at which the controls become ineffective. It then noses over and falls in a spiral at the same time spinning about a fore-and-aft axis. The controls remain ineffective until, in falling, the plans again gains a certain speed. By proper handling of the controls the spin then can be stopped and the plane "flattened out" into a glide. This maneuver not only requires skill but it cannot be executed until the plane falls a considerable distance. Unless the stall takes place at a fairly high altitude or only a few feet above the ground, as in a normal landing, a crash results. In landing a conventional plane the pilot must bring it down within about a foot of the ground at speeds varying from 45 to 65 m.p.h. before he safely can allow it to lose flying speed and settle upon the ground.

The Tanager's floating ailerons prevent accidental spin. When the plane is stalled, the slots open and, instead of nosing over, the plane merely settles in a landing attitute and, because of the extra lift of the slots and flaps already described, settles at so slow a rate that, regardless of the altitude at which the stall occurred, no injury to the plane results from landing out of the glide. These are not mere theories, but realities repeatedly demonstrated during and since the competition.

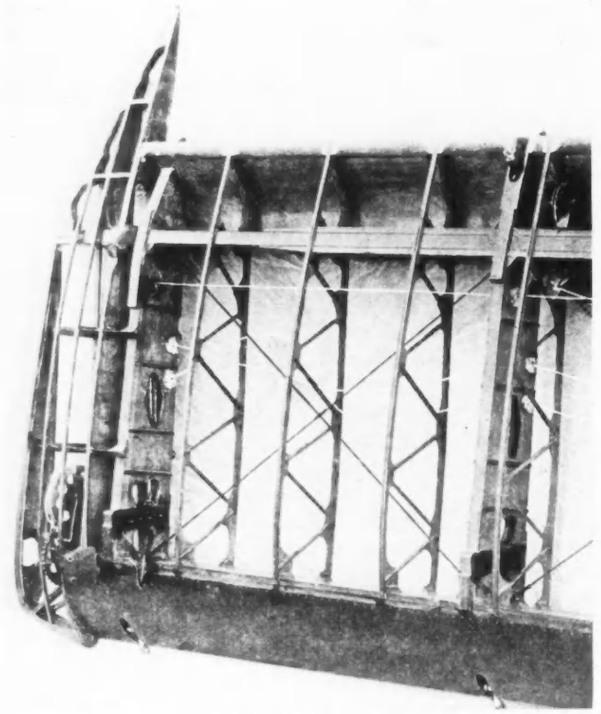
Shocks occasioned by a landing of this type naturally are much more severe than those made in a conventional landing, such as the Tanager can make even better than most planes because of its low landing speeds. The landing gear is designed to cushion this heavier shock without breakage and without more discomfort to occupants of the plane than is common in conventional planes properly landed. About twice the deflection normally allowed in landing gears can be given the Tanager gear without injury either to it or to the plane. Its oleo struts are inverted and are designed to withstand heavy bending and braking loads. The landing gear also is so arranged that it imparts no bending stresses to the fuselage,



DIAGRAMMATIC section of wing, showing approximate proportions of the airfoils that form the front slot, the rear flap with its slot, and the curved tubular support carrying the leading airfoil in grooved roller guides. Both slots have venturi sections



SIDE VIEW of Tanager with all slots open and flaps lowered. The torpedo-shaped lead projection in the foreground is merely to balance the floating aileron upon which it is mounted



DETAIL VIEW of wing structure. The box-spars, ribs, and struts are of spruce, fastened with glue and nails

which is a fault of nearly all other landing gears. The longerons therefore are relieved of all bending and torsional strains, so far as the landing gear is concerned.

Since the Tanager can be flown and banked automatically in turning by use of its ailerons and without employing the rudder, flying is simplified materially, especially for the beginner. The only added control is that for the flaps, and even this can remain fixed without interfering with flight. Only when best performance in all respects is required does the flap setting have to be changed in flight, and this is done merely by turning a crank.

In practically all respects not already discussed, the design of the plane follows conventional lines. It uses a standard 176-hp. Curtiss "Challenger" engine mounted in conventional fashion. The enclosed cabin permits of ready emergency exit for the pilot and passengers carrying parachutes and the precautions against fire are those ordinarily used.

From the foregoing it is apparent that six of the eight conditions tending to promote safety in flying, as outlined in an early paragraph, are met by the Tanager. So, also, are the other two (numbered six and seven), for in the Guggenheim tests the plane proved itself capable of gliding with power off at a minimum angle of approximately 6 deg. to the horizontal, and at a maximum angle of about 14 deg. at 37.1 m.p.h. The Tanager took off in 300 ft., cleared a 35-ft. barrier in 500 ft., stopped in 90 ft. after landing, and stopped 295 ft. from a 35-ft. barrier which it cleared in landing. In addition, the Tanager showed itself capable of flying "hands-off" controls at air speeds from 35 to 100 m.p.h. with various throttle openings and in gusty air. In the event of engine failure the plane takes up a steady gliding attitude with controls free. If the elevator is pulled back it glides at only 37 miles an hour. Some design details revealed by accompanying illustrations are deserving of comment, but enough has been said to indicate the advance toward flying safety.

Vibration in a Dynamically Balanced Machine

By Paul B. Swinton

"LAST time I was here, you were having quite some trouble with one of your motor-driven grinders on the test floor. How did you finally make out with it?"

I asked this question of the chief engineer of a prominent machine tool builder as we were walking through his test shop on one of my semi-annual visits. The chief engineer laughed.

"That was a tough problem," he replied. "You remember it was our type SX machine with the motor mounted on the arm. At the time you were here last, we were testing it, and it was vibrating like a car running on three cylinders. Of course, we started with the usual procedure; tore down the whole machine and tested all the rotating members for dynamic balance.

"We did find one or two pieces that were a little more out of balance than they should have been, but not enough to account for the amount of vibration we had experienced. The machine was reassembled and tested again. There was very little decrease in the vibrations.

"By that time we were all a little worried. We had tested every rotating piece for dynamic balance exept the armature of the motor. Someone suggested we ought to test that also, and with a rather hopeless feeling, we did so. Just as we expected, the armature was in very good balance. So there we were—no further than before.

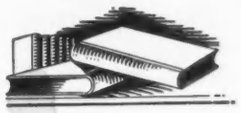
"At times luck plays an important part, and it sure did this time. Just as we were reassembling the motor, the sales engineer from the motor manufacturer dropped in to see me. I know him well, so my secretary sent him down here where I was watching them working on the machine. Naturally, the first question he asked was why we had taken out the armature. I told him of our trouble and he smiled when I said that his armature was in perfect balance. Then he asked me if we tested the motor assembled. I told him that we hadn't.

"Without stopping to explain why, he climbed up on the machine and started measuring here and there on the motor. Soon he came down again. He seemed somewhat embarrassed and asked me to replace the motor which was then on the machine with another one that we had in stock. It seemed a strange request, and he wouldn't explain it, but he was so insistent that I finally consented. We waited around until the job was finished and the machine was running again. Strange to say, the vibrations had entirely disappeared.

"Naturally, I insisted that my sales friend explain to me why the motor should have caused the vibrations in the machine. This he did frankly enough. The armature on the former motor was considerably eccentric with the field, that is, the air gap between the armature and the field was bigger on one side than the other. This caused an unbalanced magnetic field and resulted in vibrational forces in the motor that were transmitted to the machine. That was all there was to it, but it certainly had us guessing."

"'Twas a very unusual situation," I agreed. "Evidently, just because a piece is in dynamic balance does not signify that it will not vibrate."

Books for Engineers



ARITHMETIC OF ELECTRICITY. *By T. O'Conor Sloane. Two hundred thirty pages, 5x7 in. Cloth board covers. Indexed. Published by the Norman W. Henley Publishing Company, 2 West 45th St., New York, N. Y. Price $1.50.*

THIS clever little book is now appearing in its twenty-third revised edition. It consists of a simple development of the laws of electrical computation, and the placement of these into a series of rules involving only ordinary arithmetic.

Of course, the relations of the units as originally deduced by higher mathematics are not ignored, but the conclusions are taken and constants have been worked out so that in the figuring of any ordinary problem no recourse to algebra or higher mathematics is needed. There are 110 rules given in the book, covering such matters as resistance, conductance, work, batteries, magnets, inductance, heating, and electric units. Examples are given after each rule. The book makes a handy quick reference for anyone having to handle occasional electrical problems.

✦

WORK ROUTING IN PRODUCTION. *By John Younger, professor of industrial engineering, Ohio State University. One hundred fifteen pages, 6x9 in. Cloth board covers. Published by the Ronald Press Company, 15 East 26th St., New York, N. Y. Price $2.50.*

FOR THE ENGINEER whose job is design, and not production, but who ought to have a comprehensive glimpse of shop work in its various aspects, this book is admirably adapted. It skims easily over a very wide range of material, sticking closely to essential facts but giving enough detail to make each subject readily understandable. It was originally intended as a text for students of industrial engineering, but it will not be found too elementary nor cluttered up with historical backgrounds. Any designing engineer who has been out of touch with the shop, or whose shop contacts did not put him in touch with the economic reasoning behind such matters as work routing, tool control, lot sizes, overhead, and material handling, will find this book useful.

✦

THE CALCULUS. *By Hans H. Dalaker and Henry E. Hartig, University of Minnesota. Two hundred fifty-four pages, 6x9 in. Indexed. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York, N. Y. Price $2.50.*

A TEXTBOOK for a first course in the calculus, characterized by a high degree of accuracy of statement, by emphasis on basic principles, and by an abundance of carefully selected and graded exercises, this volume utilizes typical problems to show the application of various principles and methods. A large number of these practical illustrative problems are used to supply the necessary formal drill, but are planned so that the student solves them by applying a basic principle rather than by applying a memorized formula. A special effort is also made to supply problems of a geometric and physical nature because of the large preponderance of this class of problem in everyday applications.

No extraneous matter is brought up in the text to confuse the student. The subject is stated as concisely as possible, consistent with clarity of expression. Although planned as a text for a college course in the calculus, the work is readily adaptable to the engineer wishing to study this subject with its wide variety of applications, providing he has had the necessary training in mathematics.

✦

AIRPLANE MECHANICS RIGGING HANDBOOK. *By Rutherfurd S. Hartz, formerly Lieut.-Colonel, Air Corps, U. S. Army, and Elzor E. Hall, Lieut. Air Corps Res.; formerly Aviation Sec. S. C., U. S. Army. two hundred sixty-seven pages 5⅜x8⅜ in. Indexed, cloth board covers. One hundred four illustrations. Published by The Ronald Press Company, 15 East 26th St., New York, N. Y. Price $3.50.*

IN ADDITION to telling all about rigging, maintaining, inspecting, and repairing airplanes, this handbook of information and procedure presents a mass of useful information on fabric, wood and its reaction to various stresses, gluing and splicing, metal parts, airplane wire, and dopes and doping. This material was gleaned from the authors' experience gained in the Air Corps and in leading civilian institutions. It is presented in simple, straightforward, language, without theory, intended to make it a working handbook containing the essential information on materials used in airplanes, difficult to obtain because of the newness of the industry.

More than 600 questions, listed after the various chapters, stress the important points covered, assisting in fixing them in the reader's mind and in preparing him to pass a Department of Commerce examination if he wishes.

✦

PICTORIAL DRAFTING. *By John H. Hills, head Industrial Arts Department, Wilmington (Del.) High School. One hundred fifty-eight, 5½x8-in. pages, cloth-board covers. Indexed. 153 illustrations. Published by the McGraw-Hill Book Company, 370 Seventh Ave., New York, N. Y. Price $1.50.*

THOUGH intended for use in senior high school pictorial drafting classes, this text may well be used by practicing engineers to "brush up" on pictorial representation. Each part of the subject is presented by means of the principles involved, the principles then being applied to the construction of simple drawings. The work is handled in progressive fashion and is sufficiently detailed to give anyone long out of contact with drawing instruction considerable aid in his study. Emphasis is laid upon the development of neatness and accuracy. Typical chapters are: Straight Lines, Circles and Fillets, Irregular Curves, Oblique and Cabinet Drawing, Elementary Facts and Terms in Perspective Drawing, Straight Lines and Curves in Angular Perspective, Parallel or One-Point Perspective, and lastly, a summary of terms and abbreviations.

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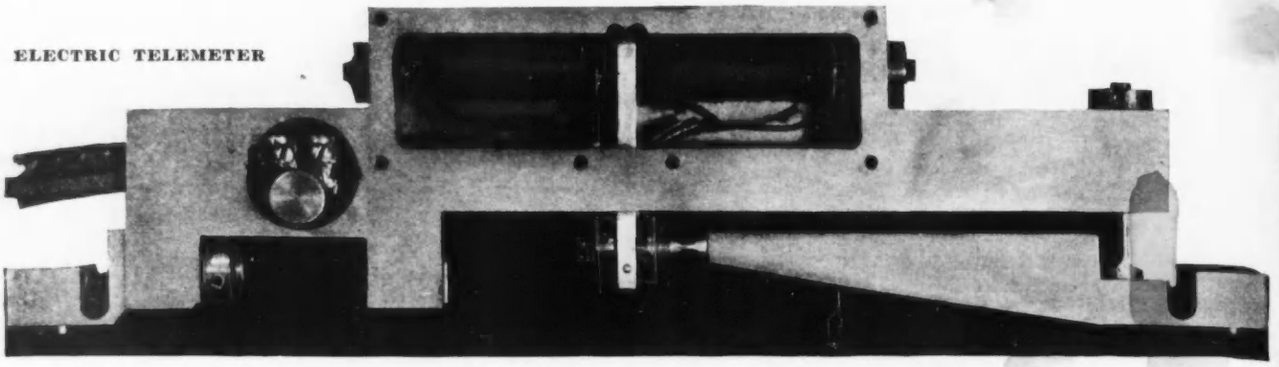
ELECTRIC TELEMETER



How they function STRAIN GAGES Why they are used

By FRANCIS G. TATNALL

Manager of Test Equipment Division, Southwark Foundry and Machine Company

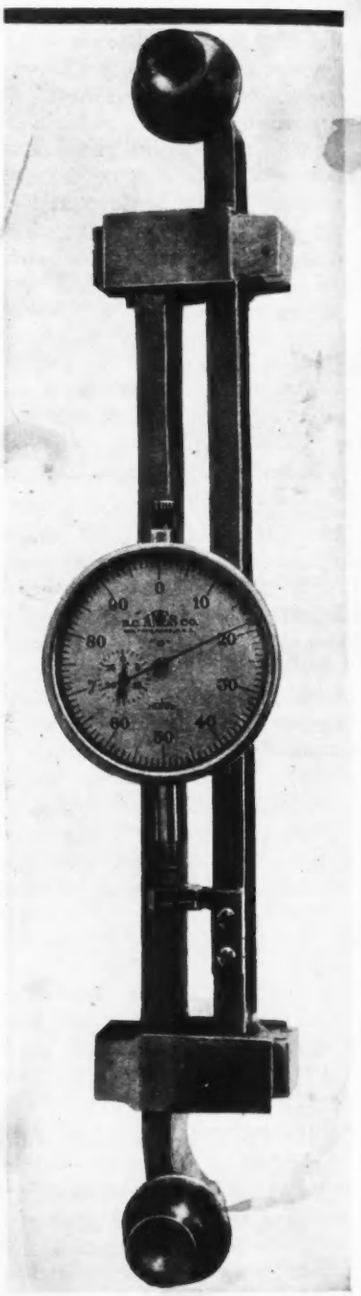
A forthcoming article will detail the procedure in making strain gage measurements and point out the common errors

NOT ALL engineering constructions lend themselves readily to a mathematical stress analysis. Holes, fillets, column effects, abrupt changes in cross-section and curved beams all give rise to stresses whose magnitude cannot always be calculated accurately; at least not without resorting to weighty equations difficult to solve and often requiring questionable assumptions.

Some engineers, when not severely limited in funds, went straight to the heart of the design problem by making full sized models of their structure and testing them to destruction on a large testing machine. But to subject a body to an ever increasing load and noting at what load and point final destruction takes place, does not tell the whole story. Frequently heavy destructive loads on one member are the result of excessive yielding in another member. Some portions of a structure may be stressed far beyond the elastic limit of the material long before the structure as a whole fails.

But to-day it is not necessary to test to destruction in order to detect the weak points in a design. As the load is being applied step by step the change in length between two established gage points on the structure may be measured and thus the stress at that section determined, the unit stress being the product of the unit strain times the modulus of elasticity of the material. In this manner the actual stress at any desired point may be obtained. It is only necessary that instruments of sufficient accuracy be used to make these strain measurements and that the measurements shall be properly taken and interpreted. The load may be applied to the structure by means of a testing machine, or by subjecting the structure to an operating load.

One type of hand strain gage is the Olsen-Lewis. A double punch is used for laying off the gage points. If the gage is to be moved successively from one position to another more accurate work will be done if small holes are drilled at the gage points. The instrument is usually held in the hand and applied successively to the various gage length under observation, the conical steel points of the instrument projecting into the drilled holes. If the instrument is to be used at only one station it may be clamped in position and the face of the dial turned to bring the zero of the scale to the pointer. If the instrument is held in the hand and applied successively, the zero reading of the instrument may be checked by means of the reference gage, which is two accurately spaced holes drilled in the side of the punch frame. By taking a reading on this reference gage before and after a series of readings on the structure, any change in the zero reading may be detected. One of the conical plugs of the instrument is rigid, while the other point repre-



WHITTEMORE gage for strain measurements

sents one arm of a pivoting lever whose motion actuates a dial gage.

The Berry strain gage also represents this type. In this instrument the movable conical plug is the shorter arm of a 5 to 1 lever, the end of the longer arm operating an Ames dial gage.

ANOTHER movable type of strain gage, operated in much the same manner, is represented by the Whittemore gage, shown in the accompanying illustration. Here the gage points move parallel to one another instead of tilting. The lever system is eliminated and the mechanism greatly simplified. As in the other two strain gages, the Whittemore strain gage uses a dial indicator to obtain the readings of deflections.

Huggenberger Tensometer, shown in the accompanying illustration, operates in a slightly different manner from that of the three previously described strain gages. A tensometer is a tiny, highly refined lever system, which multiplies the movement of the gage points by one thousand two hundred, indicating by means of a slim pointer moving across a celluloid scale in front of a mirror strip. This instrument is extremely simple and durable and consistently accurate. A number of small clamps, lugs for spot welding, and electro-magnet devices are furnished as accessories, so that the tensometer can be fixed in any position to any surface with the aid of slender steel bars called "needles." This instrument reads strain to one one-hundred thousandth of an inch. Instead of using one gage and moving it from gage line to gage line, as may be done with the Olsen-Lewis, Berry or Whittemore instruments, a number of them are fastened at the critical points of the structure and the load applied. Of course, all the gages register simultaneously, and the operator can watch from a distance the many little pointers moving across the celluloid scales. The disadvantage of this method lies in the fact that though they are comparatively inexpensive, several instruments are required.

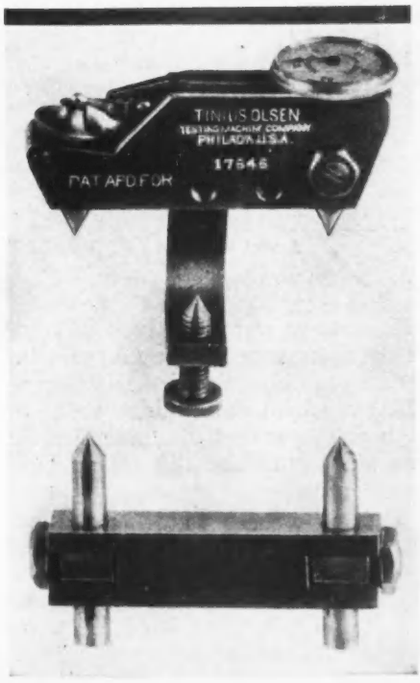
One of the newest methods of stress research is with the electric telemeter. The electric telemeter is a strain gage which translates strain movement into small electrical changes by means of a pair of highly refined resistors. These resistors are shown in the accompanying illustration. The strains from a great number of points are simultaneously transmitted over wires to a central switchboard, where the operator may read the strains by closing switches, the reading appearing on a calibrated milliammeter. The great advantage of this method is that the operator is not required to climb all over the structure and hold the measuring instrument in awkward positions, but instead remains comfortably seated at a table where he may conveniently record the data.

By the proper manipulation of any of these instruments the stress distribution may be plotted out on a drawing board, the over-stressed sections quickly revealing themselves and show where additional material is required. Similarly the understressed sections suggest the removal of excess material. In this manner the engineer is enabled to obtain a structure which will be nearly equally stressed throughout. Investigations of this nature are particularly valuable in determining the stress conditions at bends, fillets and abrupt changes in cross-sections.

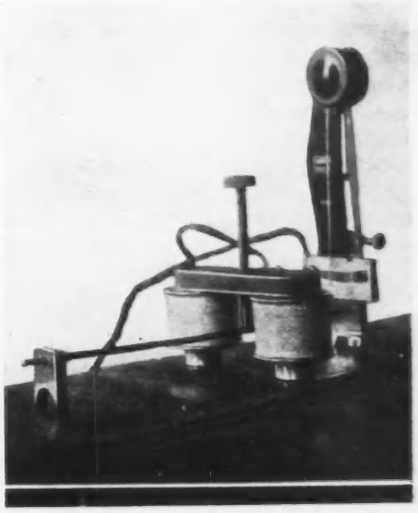
Not only may the effect of statically applied loads be determined by means of the electric telemeter, but these instruments may be mounted at many points on the finished product, be it a bridge or crane, a railway car, ocean liner, airplane, or anything that moves and is subjected to live loads and impact. The wires from the telemeters are, in the regular manner, taken to a central portable switchboard located at any convenient point. In addition, a second set of wires may be led off to an oscillograph in order to record on a moving sensitive film, small current changes in the transmitter circuit which are thus charted into parallel records of live load impact and vibration. As many as twelve such records may be made simultaneously, side by side. The oscillograph elements are so sensitive and so nearly devoid of mass and consequent inertia effects that they can record frequencies of impact effects up to 2500 impulses per second, in all 12 circuits. With the telemeters attached to parts of a vehicle and the portable recorder carried in the vehicle, the vehicle can be operated on the roughest roads at the highest speeds and a complete stress, impact and vibration record in all its critical parts be obtained on a continuous film.

BY THE use of instruments described above scientific stress investigations may be made to point the way to a more economical distribution of material. When material is properly distributed throughout a structure in accordance with a uniform stress diagram, the most graceful and pleasing final result is usually obtained. In our present industrial era the war of competition has changed its tactics and is now being waged in the engineering departments and research laboratories. In a scientifically investigated structure there is usually a net saving in weight, and if such saving in material is a factor in the sales price, there is a distinct commercial advantage.

OLSEN-LEWIS strain gage



HUGGENBERGER tensometer, used in a fixed position. It measures strains to 0.00001 in.



Progress in MATERIALS

as seen at the A.S.T.M. and I.M. meetings

By GEORGE S. BRADY

VARYING CONDITIONS of service in plain bearings demand properties in the bearing metal that cannot be found in any one type of metal, is a truth that was accented by Clair Upthegrove, at the A.S.T.M. meeting, Mar. 19, in a paper on automobile bearing metals. He also brought up the question, however, as to whether or not the existing great multiplicity of bearing-metal compositions is really necessary. In the considerations of the babbitt metals recommended for automobiles there are wide variations, but the lead-base babbitts have apparently been definitely ruled out of this service, and in the tin-base metals the amount of lead is limited to 0.35 per cent. Bronze bearings find more application in motor vehicles than the white-metal bearings, and the compositions are also found to vary so widely that it seems like a matter of personal opinion. Nickel up to 3 per cent has been added to the composition of some bronzes, but there are opinions that the use of nickel in bronze increases the friction. There is yet much to be done in the matter of bearing-metal research.

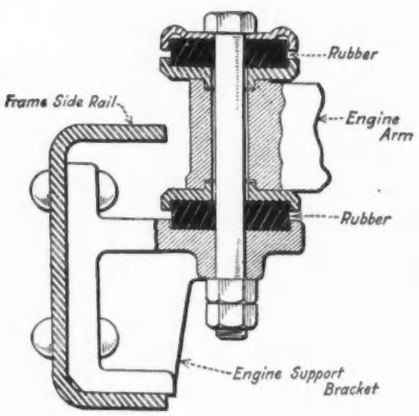
In a paper on "Sheet Steel for Automobiles," W. H. Graves, chief metallurgist of the Packard Motor Car Company, contended that metallurgists can tell more accurately in the laboratory that a piece of steel will work on a particular job than can be determined in the press-room. However, his statement was qualified, and the lesson to learn from the paper is that the laboratory is the place to determine accurately the drawing possibilities of the steel, while it is then up to the pressroom to secure proper design in the tools to make the draws. In inspecting steel the author recommends taking one sheet at random from every 200 sheets. Nine Rockwell and nine Erichsen test determinations are made on each test sheet.

Professor Moore's paper on "Recent Progress in Tests for Automotive Materials" accented the fact that the exact meaning of certain terms should be defined and standardized. There seems also to be need for study of such factors as "creep" and ductility.

With the modern finishing materials developed since 1922 there has not only been produced a better finished surface on the automobile body, but an enormous saving has been made in capital investment because of the reduced floor space and the fewer bodies required to be in process. These savings have been brought about by the reduced time needed for drying the modern finishes. M. J. Callahan, of E. I. duPont de Nemours and Company, also showed how the year 1923 marked a turning point in body finishes by the introduction of color coats of cellulose lacquers. The original defects of these lacquers have now been overcome, and a fine luster can be obtained on the body with them.

L. V. Redman's paper on "Phenol Resinoids and the Automobile," was in reality an excellent general review of the whole subject of phenol resin molding materials, going back to the inception of the industry by Baekeland and pointing out its development and the wide variety of uses up to the present time. Mr. Redman is director of research and development of the Bakelite Corporation. It is notable that the industry of producing these materials has increased eightfold since the war, and has doubled in the past year alone. The application as insulators is well known, but it is not so widely known that as a substitute for metals the phenol resins have surpassed all early prognostications.

Die casting is another industry that has grown with great strides. Charles Pack, consulting engineer, stated



REAR engine-support on the Federal truck, showing application of the rubber cushions for dampening vibration

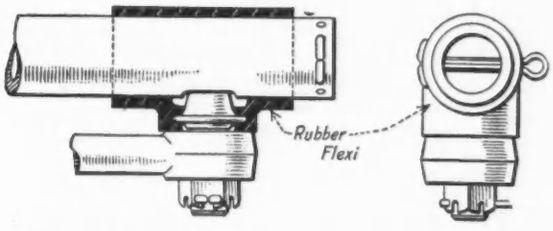
in his paper that such castings were first used in automotive production, a statement very much open to doubt, but the fact now is that probably half of the 1929 production of $40,000,000 worth of die castings are used in motor vehicles. About 70 per cent of automotive die castings are stated to be of zinc-base alloys containing more than 90 per cent of zinc.

Aluminum alloy die castings are finding their field where light weight is important, or where greater strength is required than is found in zinc. One of the newer uses of aluminum die castings is for automobile brake shoes where the high heat conductivity is of great advantage. The most generally used aluminum alloys for

die casting contain from 87 to 96 per cent of aluminum, and usually about 4 per cent of copper. Silicon is also used in some mixtures. An expensive, but excellent casting alloy is given as having 90 per cent aluminum, 4 of copper, 2 of silicon, and 4 of nickel. Apparently, something is going to result from experiments with magnesium die-casting alloys, but so far in this country they are not yet commercially practical.

One evident point that can be taken from the paper on cast iron by A. L. Boegehold, metallurgist of the General Motors Corporation, is that designers are fooling themselves by using old textbook figures for strength and other properties of cast iron. Proper uses of silicon, chromium, and nickel in cast-iron mixtures, together with modern foundry melting and pouring methods, are bound to produce iron castings far superior to the ordinary irons of a few years ago. Nickel and chromium are almost universally used at the present time in such grades as cylinder iron, and there is no longer any excuse for the designer to make his comparisons with old gray iron. A considerable amount of test material is given in the paper.

There seems to be no less than 65 different uses of rubber in the modern automobile, according to Walter C. Keys, chief engineer of the Automotive Development Department of the U. S. Rubber Company. The use of rubber in combination with other materials is rapidly



MOLDED RUBBER member used to prevent penetration of dust and water where their action would be detrimental

increasing. Rubber is being used effectively in engine supports and in spring mountings. The material is used for the dampening of vibration, for deadening noise, and for joints. Great strides have been made recently in the development of rubber compounds, and in the physical working of rubber.

UNANIMOUS approval was given by the A.S.T.M. Committee A-2 to the proposed definition of wrought iron which had been recommended by the Sub-committee on Nomenclature and Definitions. This definition reads as follows:

> "Wrought iron is a ferrous material aggregated from a solidifying mass of particles of highly-refined metallic iron, with which without subsequent fusion, is incorporated a minutely and uniformly distributed quantity of slag."

Corrosion and heat-resisting steels were well described in the paper by C. M. Johnson, chief chemist, Park Plant, Crucible Steel Company. The author of the paper aptly states that these metals are "nickel plate or chromium plate all the way through," and "only need their face washed once in a while." Silicon-chromium steels, with about 9 per cent of chromium and 3 of silicon, are valuable for heat-resisting valves. With the further addition of nickel some of these steels show also amazing length of life under severe corrosion conditions. There are now a very large variety of heat-resisting and corrosion-resisting steels, varying in their content of the alloying metals. According to Mr. Johnson, we are standing on the threshold of an almost rustless age, with the metals chromium, nickel, and silicon as the great preservatives of iron.

Standard specifications are receiving the attention of nearly all the committees of the Society. The committee on steel is giving consideration at the present time to the development of specifications for alloy-steel castings for high-temperature service, and the committee on cast iron has just approved specifications for gray-iron for valves, flanges, and pipe fittings. Corrosion of iron and steel and of die-casting alloys is being studied to an increasing extent by several of the committees. The studies include the development of testing methods, actual making of tests, and the assembly of test data from outside sources. This information is available in the reports of the committees.

PAPERS received from the London meeting of The Institute of Metals, held March 12-13, indicate that the British are "carrying on" in metals research. The research material is not of the laborious type that characterizes the German, but has much of the German, or European, thoroughness and finality of conclusion. The paper on the Aluminum Brasses, presented by R. Genders, is a very comprehensive study of the properties of the copper-zinc-aluminum alloys, and is the result of investigation and tests made by the research department at the Woolwich Arsenal.

The aluminum brasses are shown by the tests to be remarkably resistant to oxidation at ordinary and at elevated temperatures. This arises both from the aluminum as a metallic constituent of the alloy, and from the formation of a protective surface film of aluminum oxide. The composition of the aluminum brasses can be varied to give a wide range of mechanical properties, the increase in aluminum content decreasing ductility, but increasing the tensile strength and hardness. It was shown that the more ductile aluminum brasses are not more susceptible to season cracking than ordinary brass. The addition of as high as 2 per cent of aluminum does not impair seriously the workability of the alloys. The "red stain" developed on ordinary brasses in pickling is entirely avoided in aluminum brasses containing 1 per cent or more of aluminum.

A short paper by R. Lancaster and J. G. Berry, metallurgists of the Eyre Smelting Company, Ltd., fills in to an extent a gap in Charles Pack's A.S.T.M. paper by supplying test data on magnesium die-casting alloys. The alloys surveyed were zinc-base metals containing 4 per cent of aluminum and 3 per cent of copper, with only small amounts, 0.1, 0.2, and 0.5 per cent, of magnesium. The magnesium appears to cause a decrease in the zinc-rich structure and consequently decreases the hot-shortness of the metal.

That there is much of romance in the study of materials is evidenced in the paper on the "Early Use of the Metals," presented by T. A. Rickard. This paper actually deserves something more than the limited distribution it is apt to get through ordinary technical society paper printing. The paper, which is unusually long, traces back through the earliest developments of the more common metals and shows how the early uses of the metals were brought about.

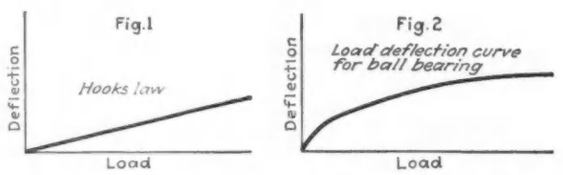
PRELOADED BALL BEARINGS for precision in machine tool spindles

By H. E. BRUNNER
Chief Engineer, SKF Industries, Inc.

DEMANDS for increased production, extreme accuracy, and high quality of finish throughout the field of precision machine tools have grown more exacting year by year. Builders of machine tools have been continually improving their designs to meet the changing methods of production and probably no part has received more careful study than the bearings on those spindles which directly affect the work done. Bearings on the work spindles must not only be very accurate and hold the spindle absolutely rigid, but must remain so in order to avoid waste in the finished product, as well as interruptions in production schedules. The economy of quantity production may be seriously offset by any failure of the bearings to retain their initial accuracy.

In general, those machines requiring such an accurate mounting may be classified into three groups:

1. Heavy duty and low speed
   Examples: Milling machines, lathes, roll grinders
2. Medium duty and medium speed
   Examples: General run of grinders
3. Light duty and high speed (4,000 r.p.m. and up)
   Examples: Small grinders, sensitive drills



AS THE LOAD is applied the contact area between the balls and race increases

It is only natural that the use of ball bearings should have steadily increased on the spindles of precision machine tools, and are now widely employed on all classes of such equipment. The ball bearing, when properly mounted, offers not only a high degree of accuracy, but also permanent rigidity, and to these essential features there are incidental advantages that are not inconsiderable. One is that the maintenance costs are a minimum because of the small lubrication requirements of the ball bearing and freedom of the latter from wear when adequately protected against the entrance of dirt or abrasive. Another advantage is that the coefficient of friction is lower than in any other type of bearing, so that more power becomes available for doing useful work, thereby increasing production.

Precision machine tools can be built with plain bearings on the work spindles that will give results in accuracy and finish quite comparable with those obtained from a well designed ball bearing mounting, but such a condition cannot be maintained indefinitely. In order to take the cuts required by a high rate of production and at the same time produce a finish that is accurate and free from chatter, the plain bearing has to be initially tight. The rate of wear in such a bearing is relatively high, and it must, therefore, be an adjustable type to permit tightening it up when wear occurs. A common method is to employ a tapered bearing split longitudinally into a number of sections. When initially assembled the plain bearing surface may be very even and free from any out-of-roundness, but when wear takes place the amount is not uniform over the entire surface. Hence, when adjustment is made to compensate for any looseness that develops, the load will be localized at the high spots and the rate of any subsequent wear increased.

IRRESPECTIVE of the type of bearing used on work or cutting spindles, whether plain bearing, roller or ball type, some form of adjustment must be used to remove all axial and radial looseness from the bearing in order to give the desired rigidity. A variety of methods have been used to achieve this end, but the principal obstacle heretofore has been the difficulty in obtaining an adjustment that is not dependent on the "feel" of a mechanic or the one who assembles the bearings in place. With all the usual designs there is a possibility that the bearings may not be adjusted tightly enough to give the desired results, or they may be pulled up too hard, imposing undue loads on the bearings. In the case of ball bearings, excessive tightening may cause ball denting of the races and if plain bearings are used the proper thickness of oil film will not be obtained, permitting a metal to metal contact with the result that the bearing will wear abnormally and possibly fail due to seizing.

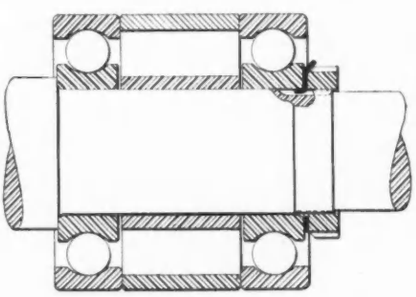


Fig. 3

BEARING in which the inner race is displaced under a predetermined thrust load. When the locknut is tightened the outer races are displaced to reform the ground contour

An ingenious method has been developed whereby ball bearings are loaded at the time of manufacture with a definite predetermined load. This advance in bearing design has resulted in removing the problem of adjust-

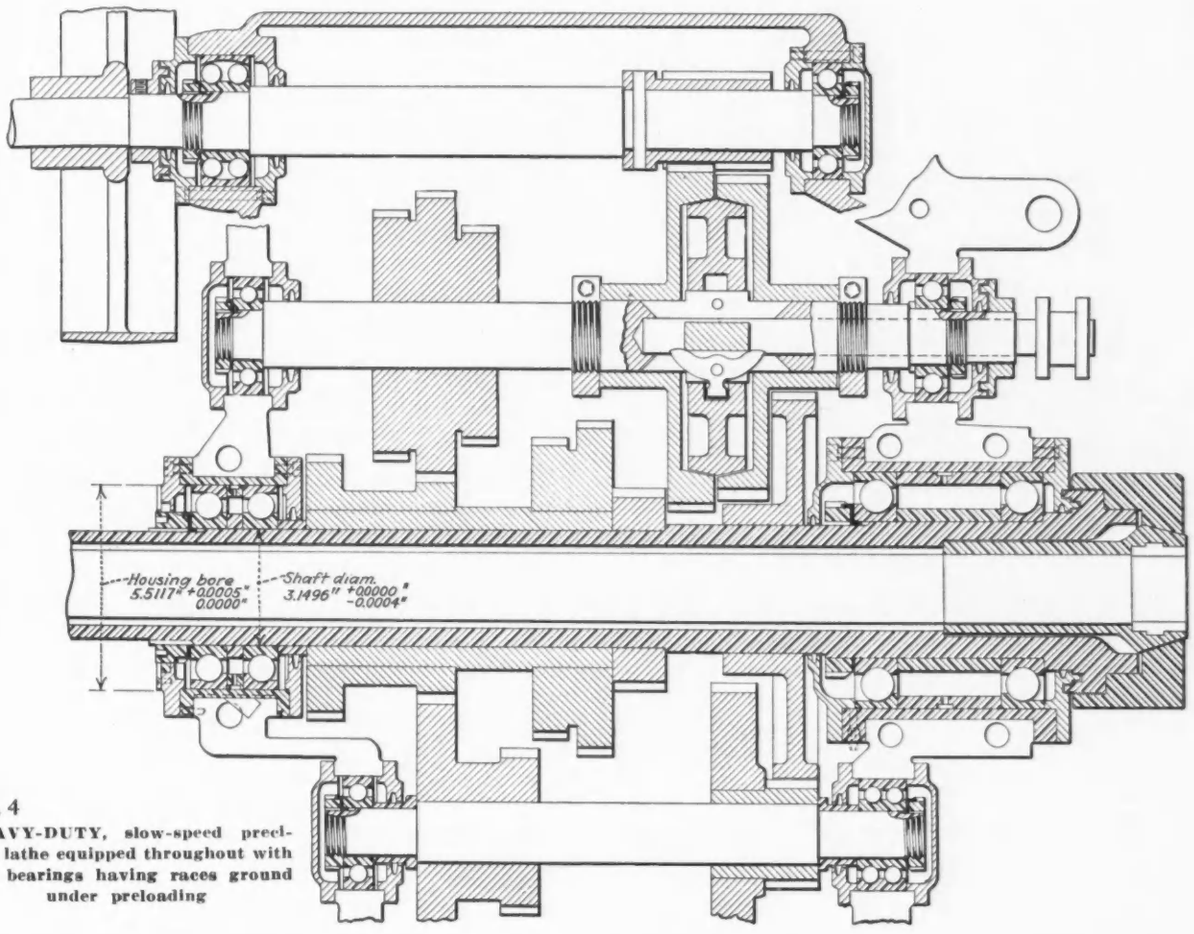


Fig. 4
HEAVY-DUTY, slow-speed precision lathe equipped throughout with ball bearings having races ground under preloading

ment from the field of chance to one of certainty, so that the exact degree of tightness necessary for smooth and accurate spindle operation is obtained. Before describing this particular design it will be of interest to discuss some of the less efficient mounting methods previously used.

If we turn to the early types of ball bearings used on the work spindles of precision machine tools we find only the standard types employed inasmuch as the production methods were not as severe as present-day standards and could usually be met with a uniform measure of success without resorting to any modification of the bearings. However, as the demands for increased production grew, and machining tolerances became closer, the standard bearings were found wanting in precision. The obvious course was to produce bearings with much closer manufacturing tolerances on all important dimensions such as the bore, outside diameter, width, squareness of bore with face, parallelism of groove with face, along with a higher degree of finish or polish on the ball paths. The improvement thus obtained was reflected mainly in increased dimensional precision, but there was not a comparable improvement in the quality of the finished work, because of the fact that no attempt was made to minimize looseness in the bearings, which is the cause of vibration or chatter. The next step was to remove all looseness or clearance between the balls and races so as to obtain a fit approximating a line-to-line. Such a bearing has proved eminently satisfactory for light duty work, such as light grinding and woodworking.

This, however, was found inadequate to meet in a thoroughly satisfactory manner the exacting demands of present-day precision machine tool requirements where comparatively heavy cuts are commonplace and machining tolerances extremely close. While a bearing may have no internal looseness initially, the balls or rollers will yield or deform under load. Reference to Figs. 1 and 2 will show two curves plotted against load and deflection. Fig. 1 is the regular curve for Hook's Law and is, of course, a straight line up to the elastic limit—deflection being proportionate to load. Fig. 2 shows the deflection in a ball bearing under load, and which is represented by a semi-cubic parabola, the reason being that as the load is applied the contact areas between the balls and races increase so that the specific ball load is not proportionate to the applied load. From this curve it will be seen that if a ball bearing can be preloaded in some manner to a point on the flat portion of the curve, the work load which is added will produce a much smaller deflection than on an unloaded bearing, and thus give a smooth chatterless finish.

A SMALL initial load can be applied to a ball bearing by using oversize balls, but by this method it is not possible to exceed about a 0.0003-in. to 0.0004-in. press fit due to assembly difficulties. Hence, the loading must come from some modification either in the mounting or in the design of bearing.

Because of the heavy axial loads which must be provided for, either the Conrad or the open side angular contact types of ball bearings are well suited to preloading. Probably the earliest method of applying such a load was to mount one bearing at each end of the spindle and displace the outer races axially toward each other by using threaded end covers. This method was successful occasionally, but only when the adjustment was

very carefully done. It was not possible in the majority of cases to produce the exact predetermined load, and therefore the method was found lacking in this respect.

Another method that aimed to accomplish the same result was to load the bearing through the outer races by means of springs. With such a design a relatively small initial load can be imposed quite suitable for light grinding, but on heavier machines where the loads are of larger magnitude vibrations will be set up in the springs and the quality of the finished work will be unsatisfactory.

A method which more nearly approximates the ideal than any other thus far described is to mount two single-row ball bearings at each end and insert sleeves of unequal length between the outer and inner races. In this way the races are displaced axially, imposing a load on the bearings, and it is not necessary to rely on the judgment of the workman assembling the unit. This method, however, does not possess any facility or means for reproducing the original loading should the spindle need repairs at any time and is, therefore, limited to one particular pair of bearings that possess their own individual tolerance characteristics. In any event, the method involves calculations and measurements to determine the proper length of sleeves necessary to produce the desired initial load.

From the foregoing it will be realized that for a mounting to be entirely satisfactory it should not only involve the feature of predetermined loading but it should be possible to interchange bearings of the same size and type freely without altering the proven requirements of the spindle. This has been fully accomplished as will be appreciated by the following description of a method wherein the amount of initial load is definitely controlled by the bearing manufacturer but by which any two bearings designed similarly can be used together. The principle followed in the manufacture of these bearings is to displace the inner race with respect to the outer race under a predetermined thrust load, and to surface grind the face of the projecting inner race until it is flush with the side of the outer race. The bearing is then reversed and the procedure repeated by applying the thrust load to the inner race again but in the opposite direction.

IN Fig. 3 are illustrated two such bearings assembled on a spindle with equal length spacing sleeves between the outer and inner races, preparatory to being drawn up and secured in place by a locknut and lockwasher. When the outer races first come in contact with the spacing sleeve which is between them, the inner races are not in contact with the spacer as the widths of the inner rings are less than the widths of the outer rings by the amounts removed in the pressure grinding. By tightening up on the locknut until the inner races are in contact with the spacing sleeve the outer races are displaced axially, and the load under which the bearings were ground is reproduced in them.

As previously stated, the single row Conrad type and the open side angular contact type of ball bearings are well suited to preloading, and have been used quite generally in this manner on precision machine applications. The choice between the two types is one of design solely.

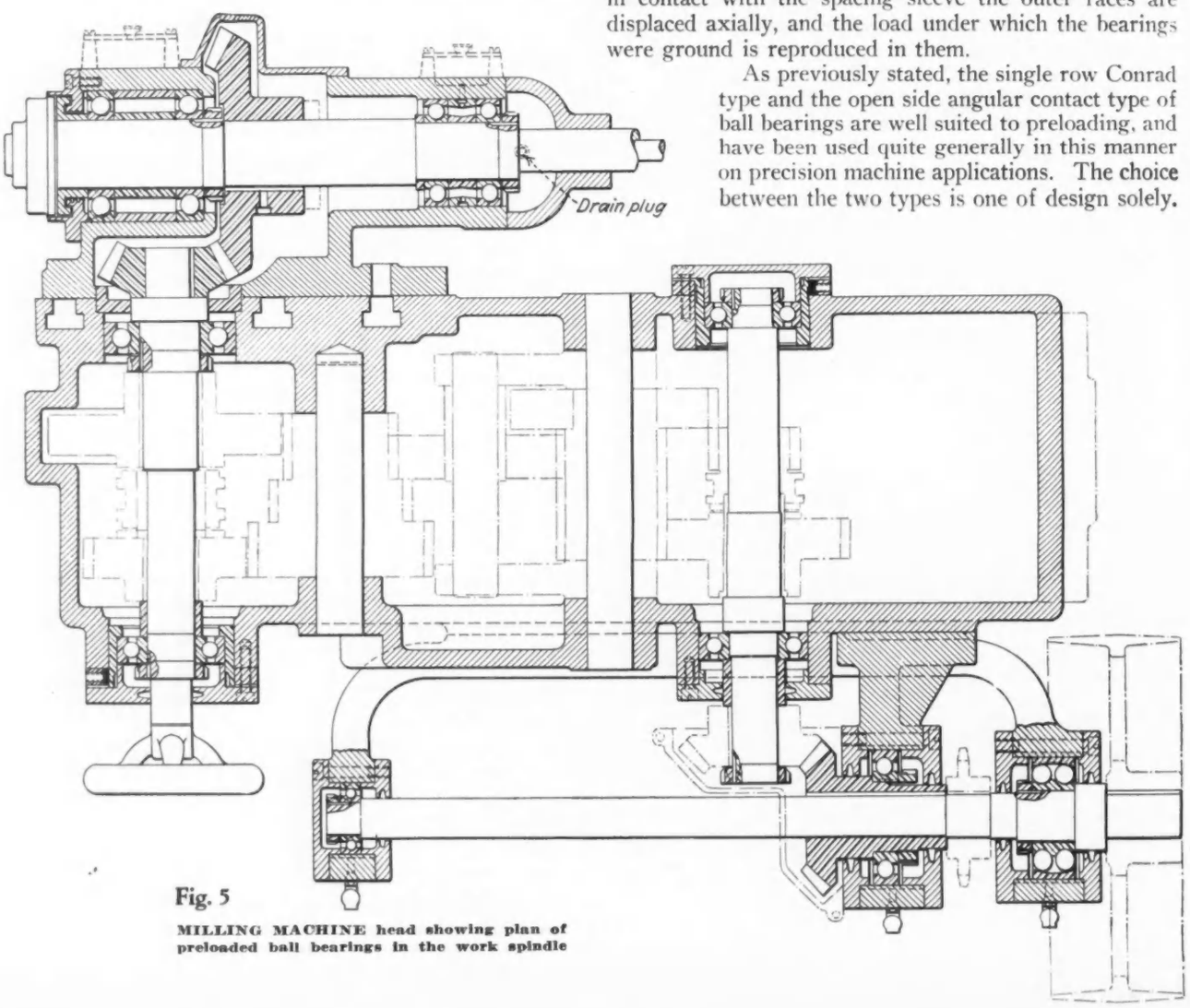


Fig. 5

MILLING MACHINE head showing plan of preloaded ball bearings in the work spindle

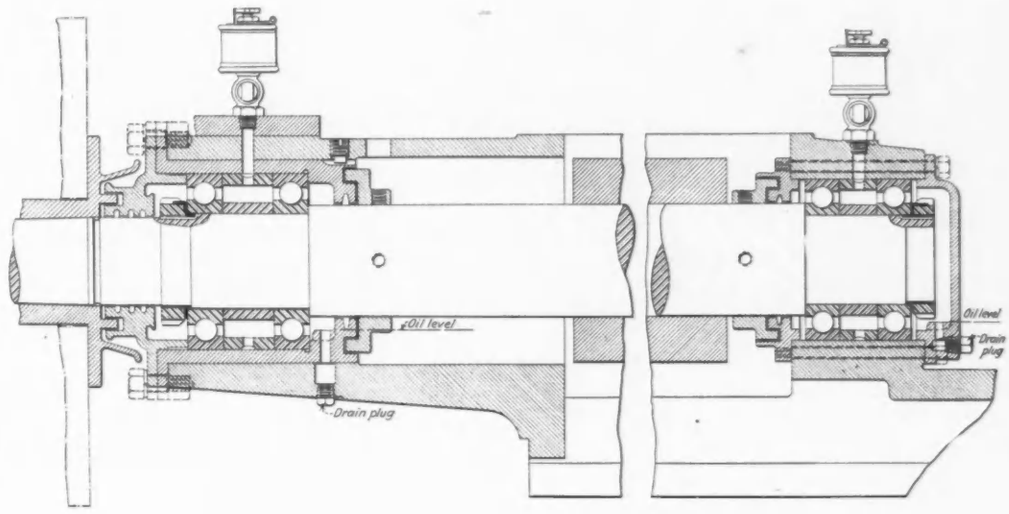


Fig. 6
ROTARY SURFACE GRINDER spindle with two preloaded bearings, and showing how lubrication is applied

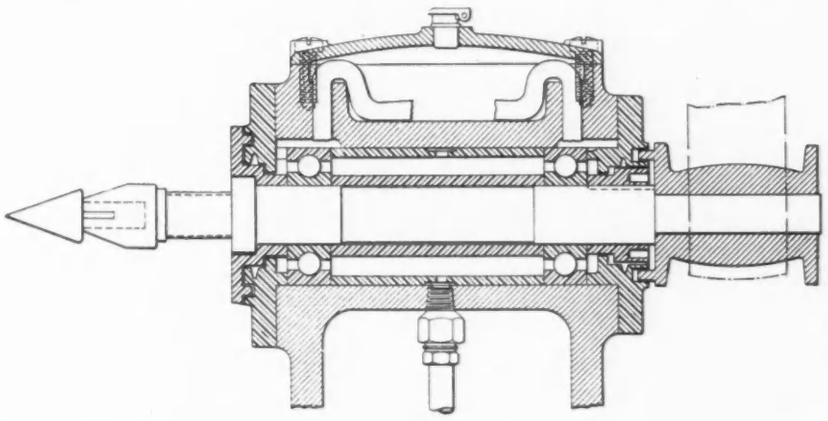


Fig. 7
HIGH-SPEED GRINDER spindle showing application of ball bearings. Single bearings are used because of the short distance between the centers

For the usual type of application the Conrad bearing can be made to duplicate the yield characteristics of the so-called angular contact type, and offers advantages which make its use desirable. As a self-contained unit that will carry thrust equally well in either direction it may be interchanged or reversed on the shaft in assembly without impairing in any way the characteristics of the matching load. The open-type angular contact bearing on the other hand, will carry thrust in one direction only, and must always be mounted so that the thrust will be taken on the high shoulder of the outer race. For certain heavy duty machines where the loads are of large magnitude the use of the open side angular contact bearing may become desirable due to the possibility of providing additional load carrying capacity in the bearing.

BEARINGS of the "built-in" loading type are used widely with uniform success on a variety of precision machine tools, and the number in use is increasing steadily. A large number of applications have been on precision grinders, and the employment of this method has also shown its usefulness on milling machines, lathes, as well as many other types of machines where the necessity for positive predetermined loading is required. In precision grinders these bearings have proved their dependability on almost every type of machine from heavy duty roll grinders to the lighter duty high speed units operating at speeds up to 15,000 r.p.m. A few typical mountings illustrating the application of these bearings will be of interest.

In Fig. 4 is shown a heavy duty, low speed, precision lathe equipped throughout with ball bearings. In this design the frame is split so that it would be difficult to machine it with sufficient accuracy to receive the outer races of the preloaded bearings on the work spindle. This has been readily overcome, however, and the assembly facilitated by utilizing a sub-housing around each pair of bearings. As a result the work spindle, bearings and sub-housings can be assembled on a bench and inserted as a unit in the frame, assuring a maximum of protection to the bearings.

THE housing seal at the front of the main spindle is of a labyrinth type to prevent the entrance of dirt or water into the bearings. At the opposite end the housing seal need not be so elaborate, and a split brass ring is used held in place by a plate screwed to the end cover.

The work spindle is located axially by holding the outer races of the two bearings at the front end between the lips of the end covers, while the pair at the rear have ample freedom to position themselves laterally in the sub-housing without affecting in any way the predetermined adjustment.

The lubrication system is not fully indicated in Fig. 4. For the work spindle an oil trap is incorporated in the upper half of the frame, and from it the lubricant is fed to each pair of bearings through a wick which not only controls the rate of feed but acts as a filter also. The lubricant enters each bearing housing midway between the two bearings, and after passing through them is drained back to the gear casing through the plug shown. The plug is drilled and fitted with a wick to prevent dirt or foreign matter gaining access through the

drain hole and working its way into the bearings.

In Fig. 5 a plan view of a milling machine is shown on which the various spindles are supported on ball bearings, but for the purpose of this article the bearings on the work spindle only need be discussed. At each location on the work spindle two preloaded bearings are used mounted with spacing sleeves of equal length between the outer and inner races to increase the rigidity. The spindle is located axially on the two bearings at the work end while the pair at the opposite end are free to position themselves axially in the housing, without affecting in any way the initial adjustment.

A wick feed system of oil lubrication is employed by means of which the oil is fed from a reservoir cast integral with the frame. At the work end the lubricant enters at the front of the housing, and after passing through the bearings drains into the gear casing. At the rear location the oil is brought in midway between the two bearings, and the equal length spacing sleeves are cambered to cause the lubricant to flow through each bearing. The used oil drains into the gear casing at one side and through a drain plug at the opposite side.

AMOUNTING for the work spindle of a rotary surface grinder is shown in Fig. 6. This design has two preloaded bearings at each end of the spindle mounted with spacing sleeves of equal length between the inner and outer races. In order to permit the spindle, bearings, and pulley to be assembled as a unit and inserted in place, the bearings at the grinding wheel end are mounted in a sub-housing. This permits boring the frame to a diameter slightly larger than the pulley diameter, thus allowing the pulley to pass through.

The housing at the end away from the wheel is closed on one side as the spindle terminates in it. Each of the other housing enclosures consists of a labyrinth flinger and oil groove. This arrangement provides an effective seal against the intrusion of dirt or water into the bearings. As an added precaution the flinger at the enclosure next to the wheel is shaped so that any water or cooling compound that may gather on it will be drained off without getting into the clearances of the labyrinth.

Lubrication is accomplished by means of sight feed wick oilers from which the lubricant is fed into the housings midway between each pair of bearings. The oil is allowed to accumulate in each housing, but when the level rises to approximately the center of the lowermost ball in the bearings it is drained off through the overflow pipe indicated.

In Fig. 7 is shown the application of two preloaded ball bearings to the spindle of a small high-speed grinder. It was possible in this case to use two bearings only, and to obtain a sufficiently rigid mounting because of the short distance between bearing centers.

It is of the utmost importance at high speed to control the quantity of lubricant supplied to the bearings, and a wick feed not only does this but at the same time filters out any dirt that may incidentally gain access to the oil supply. In the design shown in Fig. 7 an oil reservoir is formed in the upper part of the casting from which two wicks carry the oil by capillary action into the housing. After passing through each bearing the oil is drained out.

The enclosures on a grinder require careful consideration because of the fact that dust and abrasive are always present in considerable quantities. If they are allowed to gain access to the bearings serious wear will result. In the design shown a labyrinth type of flinger is provided at each end to throw dirt away from the enclosures and prevent its intrusion into the bearings. At the drive end the flinger takes the form of a lip on the pulley hub and runs in a groove machined in the end cover.

In all designs where precision requirements necessitate the use of the preloaded type of bearing, the fit of the inner race on the spindle and that of the outer race in the housing must be given special consideration. The fits must not be too heavy or otherwise the predetermined adjustment of the bearing will be disturbed. It is always recommended that the bearing seat, as well as the housing bore be ground to dimensions that will result in a fit of the inner race on the spindle ranging from a line-to-line to not more than 0.0002 to 0.0003 in. press, and a fit between the outer race and housing ranging from a line-to-line to not over 0.0002 to 0.0003 in. loose.

✦

Modified Gear Ratio Formulas

By William A. Winters

Machine Designer, Globe Steel Tubes Company

THE simple gear ratio formula presented by Jack Best on page 82 of the February number apparently got slightly distorted in the process of being printed. As made evident by the equation at the bottom of the column, the basic equation should read:

$$z = \frac{T}{R + 1}$$

The times sign appearing in the denominator, as printed, is apparently a typographical error.

Though there are many occasions where it is desirable to directly calculate the numbers of teeth in each of a pair of gears whose total number of teeth is fixed, the more usual situation is that wherein the center distance between the gear shafts is fixed, and the gear diameters are to be calculated. A suitable equation for making such calculations can readily be derived from Mr. Best's equation given above.

The number of teeth per inch of pitch diameter, called the diametral pitch, when multiplied by the number of teeth, gives the inches of pitch diameter. Hence, if we multiply both sides of the above equation by the diametral pitch we obtain the following relationships:

Number of teeth in small gear, z, times diametral pitch equals d, the diameter of small gear.

Total number of teeth in both gears, T, times diametral pitch, equals the sum of the two gear diameters, or twice the center distance, hence $2C$, where C is the center distance. Therefore multiplying both sides of the original equation by the diametral pitch we get

$$d = \frac{2C}{R + 1}$$

wherein R is the desired gear ratio. For example, if the center distance is 30.5 in. and the gear ratio is 3.4 to 1,

$$d = \frac{2 \times 30.5}{3.4 + 1} = 13.86 \text{ in.}$$

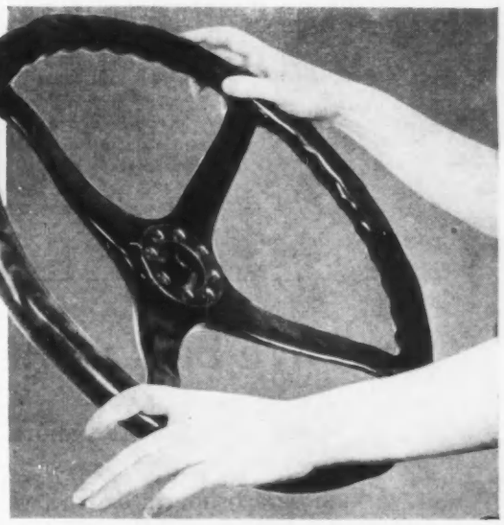
Of course, the calculated diameters may have to be modified so that for the diametral pitch chosen there will be a whole number of teeth.

WALNUT

in metal products

By GEORGE N. LAMB

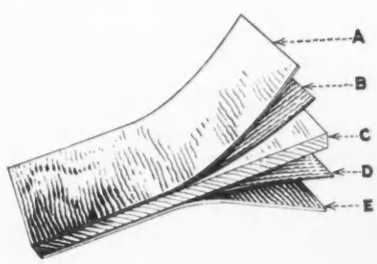
Manager, American Walnut Manufacturers' Association



AMONG the woods that are used for certain parts of the metal product, and for trim, or for cases, walnut is outstanding in several features. Its use as a material for gunstocks is well known. When polished and oiled it is soft and smooth to the touch. It does not sweat nor feel clammy. For these reasons, and because of its beauty, it is also used as a material for automobile steering wheels. Another outstanding use is for airplane propellers, where resiliency and resistance to extremes of heat and cold are required.

American walnut, (*Juglans nigra*), is obtainable in unlimited quantities because of the organized methods of growing and gathering over a wide area. The hardness of the wood is below that of oak, but its stiffness and shock-resisting ability is considerably higher. The weight is about 10 per cent less than that of oak. It has a natural brown color susceptible of a high polish, and has an endless variety of figures that are distinctive and frequently very beautiful. The development of the art of matching the figures through centuries of walnut furniture making has made it readily available for high-grade radio cabinets, automobile trim, and instrument cases. Walnut is readily worked into fine designs. It is not easily affected by weather conditions, and because it can be fitted with close accuracy and does not warp it is admirably adapted for parts and trim on metal products.

Striped figures are obtained by quarter sawing the walnut logs. Rotary figures are obtained by cutting across the growth rings at wide intervals. Burl walnut is the wood from huge knots, or burls, and has a "birdseye" or twisted figure. Matching facings are made by turning over identical slabs from the same log.



A—Walnut face veneer
B—Cross banding
C—Hardwood core
D—Cross banding
E—Walnut back veneer

Plain cut

Rotary burl

Crotch wood

THE ENGINEERING

The scene is a big contract production shop, consolidated also with an iron foundry and a nonferrous metal plant. It controls, also, a smaller shop that makes a specialty of contract production for the chain stores and mail-order houses. Conferences of the engineering and affected production executives with the chief engineer have grown into what the plant calls "The Engineering Council," which meets in a "council room" in the engineering department. Foremen are called in, and others drop

Shall We Buy or Make Parts?

"I'M SORE as a boil this morning, and I don't care who knows it," began George Overman, shop superintendent, with a smile on his face but something of fight in his voice.

"Well," added Chief Engineer Art Levering, "I have an idea of what is troubling Overman, so if it's O.K. to the rest of you I would like to have him tell his story, and then I suppose it's up to me to defend the engineering department."

"All right, go ahead," chimed in Howard Hedley, the general manager.

"Here's a machine they want us to build," continued Overman. "What it amounts to as layed out by the engineers is a bunch of parts bolted together.

"I've been in charge of the shops a long time, and we've been proud of the class of work we could turn out—I know all of the foremen are, too. But just look at this design—It's simply an assembling room job—They don't even give us a chance to make the bearing blocks—Looks as if someone had been reading a lot of catalogs and wanted to show what he knew. All I've got to say is that, if the engineers are going to do this kind of business, we can scrap a lot of our shop machines, and then get rid of some of our machine shop help."

"Fine," laughed Levering, "if you had kept up your arguments I wouldn't have to make any defense statement. Here's our side, anyway.

"On several occasions at these meetings we've talked favorably about using standard commercial parts. Now, we have put it in practice strong—at least this once. We had that folding machine to build on contract for the Jones Company, and they wanted it to go right into their production line without delay. It was a ticklish job—lot of clever movements to solve, and the two designers on the work concentrated on solving the design. They didn't want to fuss with details, and they didn't want the details to fail in service, either. Hence, they have ordered standard parts to be purchased." As he spoke Art leaned over and pointed to a gear.

"See that helical gear? It's special bronze, cut to fine accuracy. We added ten per cent to its cost to us in the estimate, and I defy the shop to beat the price for the same quality. Look at those drives! Wouldn't it be silly for us to design and build just two of those when there is a manufacturer turning them out on a production basis?"

"Not only that," interrupted Ray Sellers, the genial sales manager, "but we get dandy free publicity from incorporating some of those well-known parts into our product. I don't care how good the shop makes its bearings, for example, we're not in the bearing business, and I have the job of convincing our customers that we can make a good bearing when I ought to be selling the machine for what it can do."

"As I see it," spoke up the G.M., "this matter has several angles to it besides design and production. I'm going to appoint a little committee to report to me on the sales, cost, and management sides before I finally decide what policy is best to follow."

What do you think the committee will report? How does the designer set about to know when to order commercial parts, and when to call for them made in the shop?

COUNCIL

in. The problems are not solved for the readers, but some of the opposing opinions are brought out. Engineers and designers are invited to discuss the problem, or to present new problems for discussion. Acceptable letters are paid for at regular rates.

DISCUSSION
OF COUNCIL TOPICS

■

Appoint a Symbols' Committee

I HAVE read with considerable interest the article on "Designating Materials in Parts." This matter was discussed with interested executives of our company. It was the consensus of opinion that this suggestion was worthy of serious consideration and undoubtedly would be usable provided some simple method could be evolved for designating the various metals that are now being generally used.

It would seem like a huge undertaking, however, for any committee to attempt to cover by symbols the large number of different metals in general use, together with their physical properties. It is also rather doubtful as to whether all manufacturers would care to broadcast to the trade the different types of material, together with their physical properties, that are being used in the more important parts of their product.

Certainly no harm can be done by appointing a committee to work along these lines for we all agree that "nothing ventured, nothing gained."

—A. H. D'ARCAMBAL,
Consulting Metallurgist,
Pratt and Whitney Company.

■

Shall Past Advertising Control Development?

TWO FACTORS in our company's practice tend to eliminate any reactionary effect of past advertising. Our advertising must cover such an extreme variety of product that general characteristics such as quality, appearance, and service are usually stressed instead of specific features of design. Also our company prides itself on its progress in research, design, and manufacture.

Naturally, any change for the better will fit nicely with such an advertising background. The greatest retardment is the sales department itself. Salesmen seem to think that because the successful conclusion of their interview will result in the physical transfer of certain materials, formed and combined in a particular way, that what they should discuss is how and why the materials are just as they are. They are likely to forget that all the prospect cares is how much the contrivance will earn for him on the investment, and what assurance there is of continued dividends.

The result is that some promising ideas are frozen out. A new organization has been developed for cost reduction purposes. When one of this organization's promotions is arbitrarily rejected, the idea may be presented to the vice-president to obtain a showdown.

—W. W. EISENWINTER.

■

Machinery Builders Must Co-operate

THE CONFUSION that has existed in the past in connection with motor mountings results from a lack of coordination between the electrical industry and the machinery industry.

No individual machinery building concern can do anything by itself in the way of eliminating the great cost that accompanies this confusion. No small group of machinery builders could do much in that direction, because the percentage of the business in motors that comes through any one group of machinery builders is rather small. When this small percentage is split up among a number of electrical manufacturers it is still smaller. The individual electrical company cannot afford to make standards for each individual machinery builder or perhaps for any group of machinery builders.

The electrical companies are merchants enough to sell their motors to the individual user. Then the machinery builders of all sorts must apply the motor specified. They must expect this condition to continue unless and until the machinery builders co-operate to do something that will get them standardized mountings.

The machinery builders must unite in a definite movement that will eventually produce standards that are needed. The law of supply and demand will work for them, if they make a concerted demand for standardized motors.

This is only one of many things for which the machinery industry requires some definitely organized body, through which co-operative or concerted effort can be exercised for the benefit of the general machinery industry of this country. The preliminary steps looking toward such an organization have already been initiated. A committee on organization has been appointed by the informal conference of machinery and equipment trade associations. It is expected that in time the machinery business of the United States will have a contact body through which subjects of common interest can be cleared, and through which concerted action can be organized whenever necessary.

—ERNEST F. DUBRUL, *Gen'l Manager,*
National Machine Tool Builders' Association.

■

Shall Past Advertising Control Development?

THE SALES MANAGER who opposes engineering development merely because it represents a change or even a reversal of ideas, is unconsciously underestimating the intelligence and knowledge of his customers, while he is at the same time casting a doubt upon his own understanding of the points he has been selling on. More particularly, the sales manager through the direct contact of his organization in the field, should really be the first one to recognize the need for change. Development in this day in all fields is far too rapid to permit any organization to stand pat on their product. No truer words have been printed than those on a large sign in one of the Niagara Falls power plants—"Tradition is the enemy of progress."

Conversely, a good sales manager is a practical stop gap on an over enthusiastic design department given to too rapid and novel changes. "Tricky" design, no matter how ingenious, is not necessarily good design. If the sales manager can offer logical reasons for opposing a design, it is his privilege and duty to do so. If he has been contacting his customers properly, and knows whereof he speaks, he should be able to do this convincingly.

The ideal condition should be represented by a spirit of intimate contact between sales and design. Neither should spring ideas on the other as mere opposition to well formulated plans of the other. Proper cooperation will eliminate any "crisis" before it reaches that stage. Both functions are essential to each other and neither can succeed without the other.

—LEWIS J. YAPP, *Design Draftsman,*
Naval Aircraft Factory.

CAM AND CRANK LAYOUT

By GEORGE J. FREY

Ohio Mechanics Institute

DESIGNERS are sometimes called upon to lay out a pair of cam-operated cranks which must fill the requirement that either crank will remain stationary while the other is rotated through a definite angle. Probably the most familiar construction of this type is the cam-operated belt shifter mechanism used on planers, which is shown in Fig. 1. The conditions of operation in this instance require that both cranks, *M* and *S*, will direct the belts onto the loose pulleys when the planer is not operating. When the cam *Q* is rotated about its center *O* by a movement of the rod *W*, one of the cranks, either *M* or *S*, depending on the direction of rotation of the cam, will shift the belt to the tight pulley while the other crank remains stationary.

WHEN MAKING THE LAYOUT for construction, the centers *K* and *L* should be selected so that the cranks will have equal rotation to both sides of the center lines perpendicular to the line *KL*. The length of the long arm of the cranks is chosen to meet the conditions of the design. In this way the required amount of angular rotation of the crank arms is obtained, the extreme position of the crank arms, in this instance, being determined by the distance the belt must be shifted. The angle between the arms of the bell cranks will be made so that with *S* in its extreme left position, the center *E* will lie on the line *KL*. Similarly with *M* in the extreme left position, *J* will lie on the same line *KL*. The cam is to be rotated through the same angle as that through which the bell cranks are to be rotated. The center of rotation *O* of the cam *Q* will be taken somewhere on the line which is the perpendicular bisector of the line *KL*, as shown.

On the basis of these relationships the required cam profile may be obtained. Referring to Fig. 2, the line *KL* is drawn equal to the length *2A* in Fig. 1. Designating the angle of throw of the shifter cranks as α, then angles *LOP* and angle *KOP* will each be made equal to $1\frac{1}{2}\alpha$. This locates the center *O* of the arc *KBJL*. The angles *BOP* and *JOP* are each made equal to $\frac{1}{2}\alpha$. The chords *KB* and *JL* are then drawn. The points *E* and *H* are the intersection of the radial lines *JO* and *BO* with *KL* the center line.

THE CAM CURVE will consist of the circular arc *DE* with center at *O*, the arc *JL* with center at *O*, and the harmonic curve *EJ* which is plotted in the usual manner. The length of the shorter arms of the bell cranks will be equal to *KE* or *HL*.

To prove the correctness of this construction it is merely necessary to show that when the cam is rotated through the angle α, one bell crank will be rotated through the same angle while the other remains stationary. To prove this, referring to Fig. 2, consider the short arm of the left crank to be in the position *KE*. Evidently if the cam be rotated counter-clockwise through the angle α, the arm *KE* will be rotated to the position *KB* as the point *J* in the cam path will then have moved to *B*, its new position. It is therefore necessary to prove that the angle *BKE* is equal to α, the angle of rotation of the cam. This angle *BKE* is the same as the angle *BKL* inscribed in the arc of the circle *KBJL*, and is therefore measured by one-half of the subtended arc *BJL*. Also, the central angle *BOL* which by construction is equal to 2α, according to plane geometry is measured by the subtended are *BJL*. Hence the angle *BKE* must be equal to α, the desired rotation.

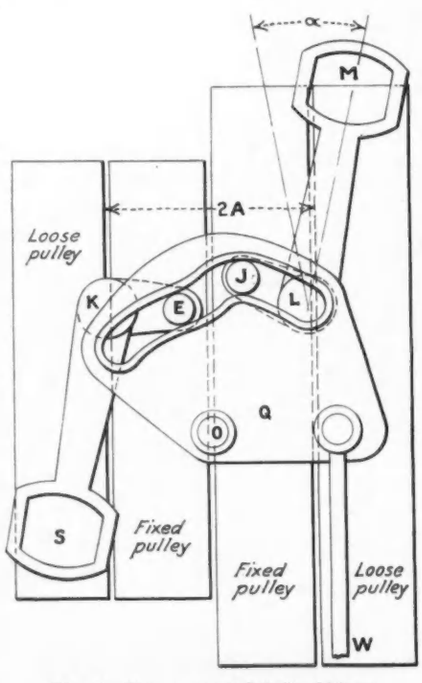


Fig. 1—Cam operated belt shifters

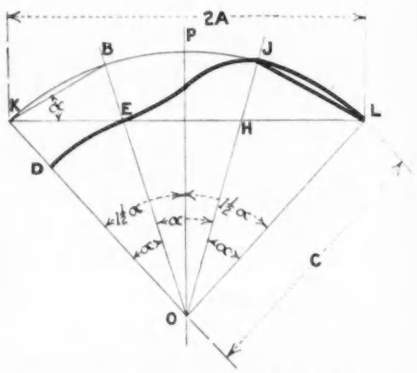


Fig. 2—Construction for laying out cam path

THAT THERE WILL BE NO MOVE of the crank *JL* during this period of the cam motion is evident from the fact that as the point *L* in the cam path moves to *J*, the latter point on the crank arm remains stationary as this portion of the cam path is the arc of a circle; it is, a dwell on the cam.

The radius *OG* may be calculated instead of being found by construction. Thus, if *A* is one half the distance between crank centers, it can be seen from Fig. 2 that the radius *C* is equal to $\frac{A}{\sin 3\alpha/2}$ Similarly, the cranks *KE* and *JL* may be calculated.

WORM GEAR DRIVES

In this last of a series of articles the author shows how contact area, line of contact, and gear tooth forms are analyzed by plotting the established equations.

By EARLE BUCKINGHAM

Associate Professor of Mechanical Measurements, Massachusetts Institute of Technology

IN A preceding article was shown the manner in which the worm thread and gear tooth form and the line of conjugate action may be plotted for different sections of a worm. In order to study the general contact conditions over the entire face of the worm gear, the several worm thread sections with their lines of action may be plotted together directly from the co-ordinates given by the original equations of the helicoidal sections, as was shown in the preceding article. When these are all plotted on a single drawing, the field of contact and the positions of the contact lines between the worm threads and gear teeth can be established by simple projection. In Fig. 1 this has been done.

The field of contact is plotted as follows: The approach action begins where the circle representing the outside diameter of the worm gear corresponding to the section of the worm under consideration, crosses the line of action corresponding to that section. This point is then projected up into the plan view to the corresponding section as indicated by the dotted line and the letters *a* and *a'* in the figure. In this way the boundary of the field of contact on the approach side is plotted. The recess action ends where the line representing the top of the thread of the worm section crosses the line of action of that section. This point is then projected up to the plan view as indicated by the dotted line and the letters *b* and *b'* in the figure. These projected points when connected form the boundary of the field of conjugate action at the recess end. By connecting all of the projected points with a smooth curve, the outline of the projection of the field of contact is obtained. This field represents the projected area in which contact takes place on the worm.

The line of contact between the worm and the worm-gear teeth may be projected into the plan view in a similar manner. It is merely necessary to project to the plan and end views the point where the thread profiles cross their own lines of action. These projected points are then connected with a suitable line. The thread profiles are then shifted axially a distance equal to the circular pitch, and the new points where these thread profiles cross their own lines of action are projected to the plan and end view and connected as before. This process is repeated until the position of all these projected contact points which lie inside the field of contact are established.

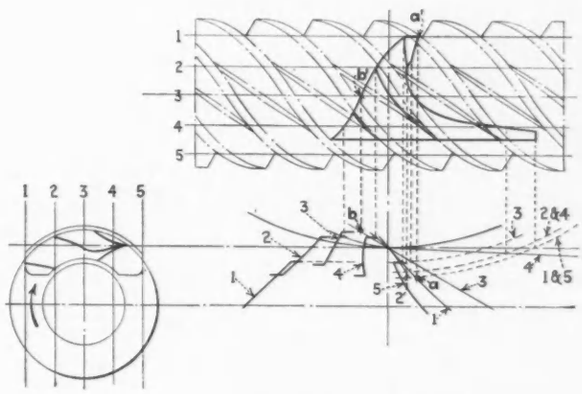


Fig. 1 FIELD of contact and contact lines projected into plan and end view

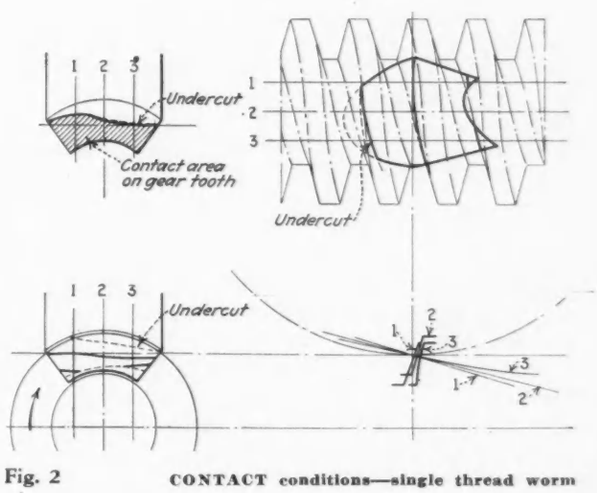
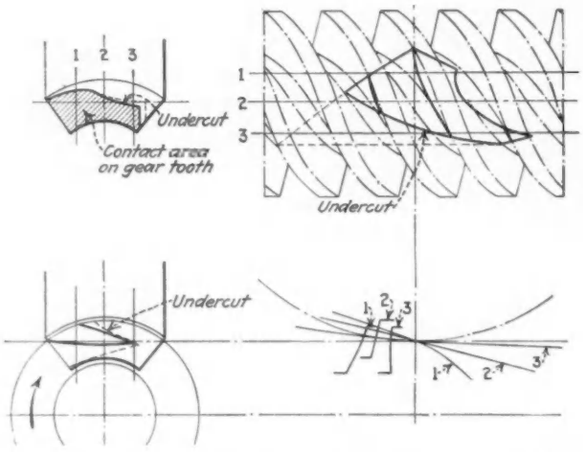


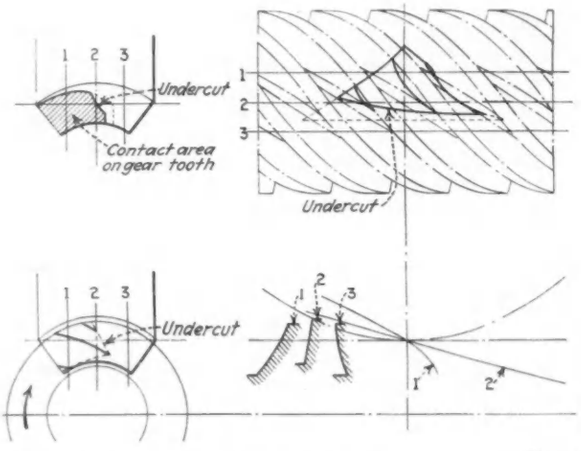
Fig. 2 CONTACT conditions—single thread worm

The shifting of these profiles is easily accomplished by making a tracing of the thread profiles and then shifting this tracing axially a distance equal to the circular pitch.

The projection of the actual contact lines between the worm and the worm gear on the end section of the worm are of importance when considering lubrication. As noted in the first article of this series, the most favor-



CONTACT conditions—four thread worm Fig. 3



CONTACT conditions—eight thread worm Fig. 4

able condition of lubrication is obtained when the contact lines between the worm and the worm gear approach radial lines.

In order to illustrate the value of the practical application of the methods here presented for analyzing the action of a worm and worm gear, the final diagrams of the plotted equations are presented for three different worm drives. These drives are alike except for the number of threads. Each has 1-in. circular pitch, $14\frac{1}{2}$-deg. angle, 25 teeth in the worm gear, 2.500-in. pitch diameter of worm, and the end faces of the gear teeth have an included angle of 75 deg. The first drive uses a single thread worm, the second a quadruple thread, and the third an eight-thread worm. The lead of the threads changes to conform to the number of threads, the pitch remaining the same.

Applying the established equations, and plotting the results in the manner as previously described, the field of contact, lines of action, and contact lines are obtained as shown in the illustrations. The worm thread and gear tooth profiles in the central plane and these profiles on planes away from the central plane, are also plotted. These are illustrated in Figs. 2 to 10, inclusive.

Comparing the single, quadruple, and eight-thread worms, it will be noticed that the field of contact and the contact area on the gear tooth, rapidly diminish as the number of threads increase. For the eight-thread worm, Fig. 4 shows that almost all of one side of the gear tooth does not contact, indicating that if the gear were operaing in only one direction almost half of it could be cut away without affecting its action.

Undercutting of the teeth of the gear has an important bearing on the field of contact and contact lines. The amount of undercut is different on the various planes as shown in comparing Figs. 7 and 10. To one side of the central plane it may be more, while to the other side less, than at the central plane. The amount of undercut may be decreased by increasing the number of teeth. This will result in a larger field of contact and possibly also additional contact lines. The dotted outline in the plan views of the projected field of contact shows the increased extent of the field of recess action that would be obtained if undercutting of the gear teeth were not present. An additional contact line, as shown by the dotted line in the end view, would also be present

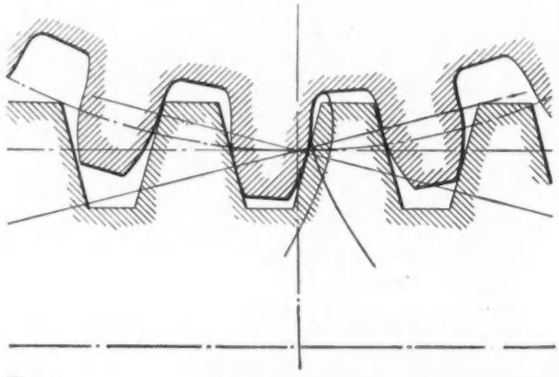


Fig. 5 WORM THREAD and tooth profile at central plane—single thread worm

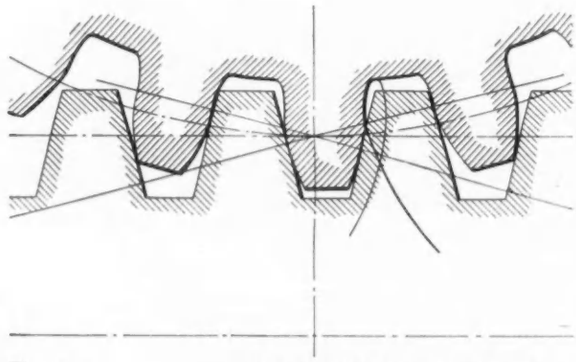


Fig. 6 WORM THREAD and tooth profile at central plane—four thread worm

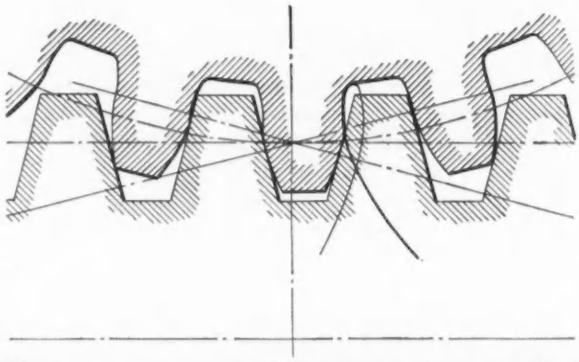
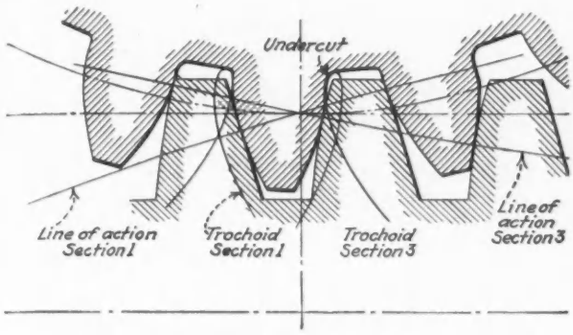
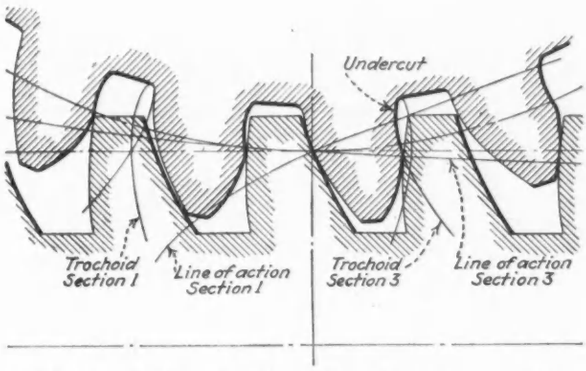


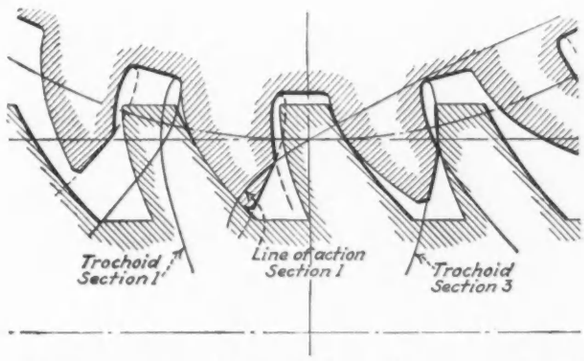
Fig. 7 WORM THREAD and tooth profile at central plane—eight thread worm



WORM THREAD and tooth profile at planes one inch off center—single thread worm Fig. 8



WORM THREAD and tooth profile at planes one inch off center—four thread worm Fig. 9



WORM THREAD and tooth profile at planes one inch off center—eight thread worm Fig. 10

if the undercutting of the gear teeth were eliminated.

When the lead angle on a worm with a 14½-deg. thread angle becomes greater than about 18 deg., the contact area on the worm-gear tooth begins to be reduced very rapidly, as shown. In order to obtain contact across the full face of the worm gear, the thread angle should be increased. It is apparent that a 14½-deg. thread form should not be employed on worms with lead angles greater than about 18 deg. The undercut is also excessive on worm gears with but 25 teeth, even with the lower lead angles. Much better contact conditions would exist if a larger number of teeth were used for the worm gear. It is good practice to use a minimum number of teeth, in worm gears meshing with 14½-deg. worms, of about 40 instead of 25 as recommended in some handbooks.

Further analysis shows that if the angle of the thread form be increased, the lead angle for equally favorable contact conditions will be greater. On the entering side of the worm gear face the sectional profiles of the worm thread show an increase in the average thread or pressure angle. The greater the lead angle, the greater this increase becomes. On the other hand, on the leaving side of the worm gear face the average pressure angle of the section of the worm thread becomes less than that in the axial section, and the greater the lead angle the greater the reduction. Therefore, with the larger lead angles greater angles should be used for the worm thread form. The American Gear Manufacturers' Association recommends the use of the 14½-deg. thread form for single and double thread worms only, and 20-deg. thread form for triple and quadruple thread worms.

It is evident from the brief illustrative examples given here, that the method of analysis presented enables the designer to make a complete study of the action of a worm and gear. It enables the designer to visualize the effects of changes in thread form angle, pitch, lead, location of pitch plane, tooth proportions and all the other factors that enter into the functioning of a worm and its gear. By this means the designing engineer can intelligently select that type of worm drive most favorable to the conditions to be met.

✦

Simplified Gashing Angle Formula

By Manïous Gottlieb
Designer, Smith, Drum & Company

THE formula commonly used for obtaining the gashing angle of worm gears employs the circular or linear pitch and circumference of the pitch diameter of the worm. When diametral pitch gears are used, the diametral pitch must first be converted into circular pitch for use with that formula.

Since the modern trend in worm gearing is toward diametral pitch gears it may be well to lay aside the old laborious formula for one that deals directly with the pitch diameter of the worm and the diametral pitch. Hence we have the simplified formula:

a = Gashing angle
D = Pitch diameter of worm
P = Diametral pitch
N = Number of threads in whole worm (1 if single; 2 if double; etc.)

$$\text{Cot. } a = \frac{D \times P}{N}$$

Example: Find the gashing angle of a worm gear for a double threaded worm 2-in. pitch diameter and 6 diametral pitch.

$$\text{Cot. } a = \frac{2 \times 6}{2}$$

Cot. $a = 6$
Gashing angle a = 9 deg. 27 min.

The A.G.M.A. recommends that the following circular pitches be regarded as standard:

$\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, 2

This series of worms (1 to 4 threads) is to cover gear ratios of from 10 to 1 up to 100 to one.

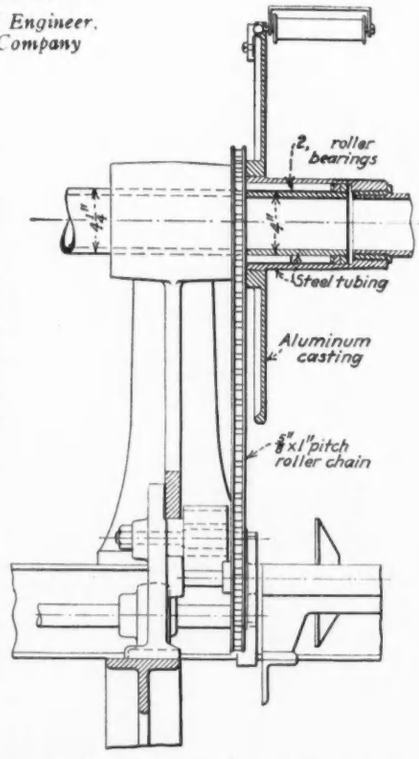
Designing Special Machines around STANDARDIZED COMMERCIAL PARTS

By C. E. BILTON
President and Chief Engineer, Elwood Electric Company

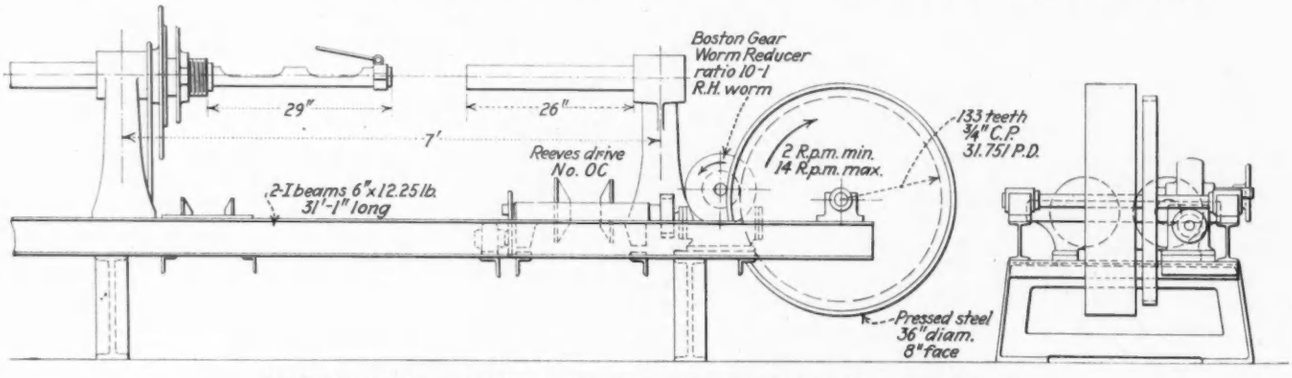
THAT it is entirely practical and economical for the designer of special machinery to use standard stock commercial parts and units in his design is well shown in the insulating machine built by the Elwood Electric Company, Bridgeport, Conn. There is a tendency among shops doing this kind of work, and sometimes also among larger production plants that design and make their own special machinery, to make as many of the parts as possible in their own works, although in most cases an examination will show that their machine shops are not adapted to do as economical work as the manufacturer who is fitted up to produce the specialized parts or units on a production basis. This can be largely corrected by the designer himself in the planning of his machine. He will usually find that such commercial units are of superior construction, and by choosing with care he can pick units that are nationally known and thus give his sales organization the advantage of the advertising of the parts and units manufacturers. This latter feature also applies to the selection of materials that he calls for in the design of his machine.

The machine shown in the illustration is for insulating cable, and was built originally for the General Electric Company. It was designed to replace three types of machines: one with a single head in which the cable had to be passed four times through the machine, and two others which had inherent faults of unbalance or of changing of dies for different sizes of wire. This machine completes the insulating of the cable in one passage of the wire, and because the tape reels are operated on the main spindle of the machine, the latter is always balanced even when only two or three reels are employed.

THE view of the machine is with the guards removed and covers off the drive mechanisms. It will be noted that the main frame consists of the five special iron castings bolted to standard 6-in. I-beams, 31 ft. long, which in turn are mounted on five special leg castings. The latter could readily have been built up of stand-



DETAILS of the spindle head. The aluminum head and the outer tube which holds the guide pipe revolve as a unit on the roller bearings


Boston Gear Worm Reducer ratio 10-1 R.H. worm
29"
26"
7'
Reeves drive No. OC
2 R.p.m. min. 14 R.p.m. max.
133 teeth 3/4" C.P. 31.751 P.D.
2-I beams 6" x 12.25 lb. 31'-1" long
Pressed steel 36" diam. 8" face

ONE OF the four sections and end view of the machine. The driving motor is mounted on this end. When standard commercial parts are used much valuable drafting room time can be saved because centers and clearances only need be sketched in by the designer in his layout work

ard steel sections by welding, except that in this case weight was desired, and also because the foundry capacity was available and the welding equipment was not ready at the time.

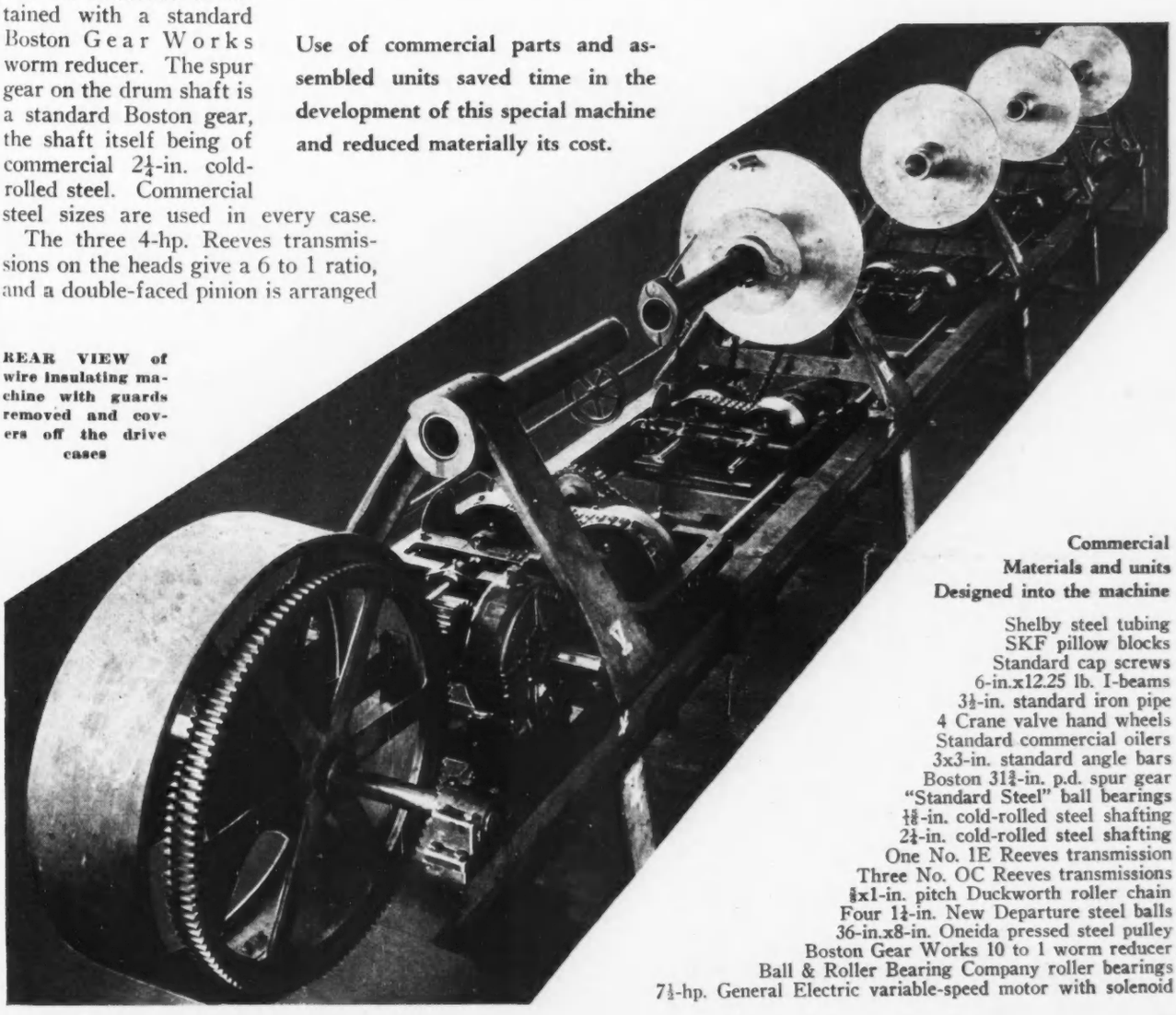
IN THE operation of the machine the wire feeds through the spindles at a constant speed and the "pitch," or lapping of the insulating tape, is governed by the speed of rotation of the heads to which the tape reels are attached. The pitch may be varied independently for each head. The feed of the wire is obtained by the simple friction of two or three wraps around the feed drum at the end of the machine. The insulated wire then passes from the feed drum directly to a reel. This feed drum is a stock pressed-steel Oneida pulley 36 in. in diameter with an 8 in. face. It has a speed of from 2 to 14 r.p.m., depending upon the type of wire being fed. The power is obtained from a 7½-hp., 1,800-r.p.m. max., variable-speed motor, with solenoid brake, and the reduction is obtained with a standard Boston Gear Works worm reducer. The spur gear on the drum shaft is a standard Boston gear, the shaft itself being of commercial 2¼-in. cold-rolled steel. Commercial steel sizes are used in every case.

The three 4-hp. Reeves transmissions on the heads give a 6 to 1 ratio, and a double-faced pinion is arranged on a bracket to be slipped over readily to give the drive in either direction, since the insulation sometimes is called for in alternate directions. The first head has a No. 1 E Reeves transmission with a 4 to 1 ratio. The main drive shaft is of 1 1/16-in. cold-rolled steel supported by standard SKF split pillow blocks. The motor control shaft runs the whole length of the machine in order to give the operator control in any position. It is of 1/16-in. cold-rolled steel, also supported on commercial pillow blocks. The four hand wheels located on the shaft are stock Crane 9-in. valve wheels bored out to fit.

The head shown in the illustration is an example of simple but effective design. The 4¼-in. Shelby steel tube acts as a stationary spindle for the cast aluminum reel head, and it also protrudes a distance of 26 in. from the spindle bracket in order to carry extra reels so that the wire does not have to be removed for application of a new reel of tape. The end of the tube is hardened and ground for a length of 6 in. to take a roller bearing, which in turn is encased in a larger tube. Two "Danbury" roller bearings 3 in. long were actually used and held in place by collars threaded and pinned to the inner tube. The slotted cable protector, through which the insulating tape feeds, is made of standard 3½-in. iron pipe. Duckworth ⅝-in. x 1-in. pitch chain drives from the transmissions to the sprockets on the heads. The sprockets are also commercial.

BY MEANS of reducing bushings, smaller sized pipe can be used for light cables. The tape guide on the spindle head is shown in one of the illustrations. It is equipped with "Standard" ball bearings, and is tilted by means of a ball and socket joint. The ball is a stock commercial New Departure 1¼-in. ball which was annealed and drilled to suit. It will be noted that the tape is passed from the reel clamped on the spindle over

Use of commercial parts and assembled units saved time in the development of this special machine and reduced materially its cost.



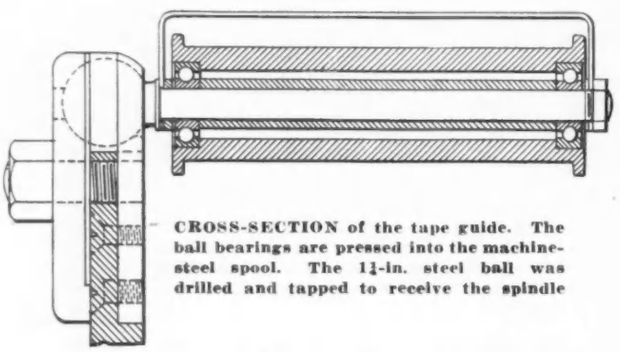
REAR VIEW of wire insulating machine with guards removed and covers off the drive cases

Commercial Materials and units Designed into the machine

Shelby steel tubing
SKF pillow blocks
Standard cap screws
6-in.x12.25 lb. I-beams
3½-in. standard iron pipe
4 Crane valve hand wheels
Standard commercial oilers
3x3-in. standard angle bars
Boston 31¾-in. p.d. spur gear
"Standard Steel" ball bearings
1 1/16-in. cold-rolled steel shafting
2¼-in. cold-rolled steel shafting
One No. 1E Reeves transmission
Three No. OC Reeves transmissions
⅝x1-in. pitch Duckworth roller chain
Four 1¼-in. New Departure steel balls
36-in.x8-in. Oneida pressed steel pulley
Boston Gear Works 10 to 1 worm reducer
Ball & Roller Bearing Company roller bearings
7½-hp. General Electric variable-speed motor with solenoid

this tape guide and thence over a rod into the slot in the pipe. This arrangement is clearly shown in the illustration of the machine on the preceding page, and in the drawings.

Speed in the delivery of a special machine is very frequently an outstanding point in the awarding of the contract, and there is probably no better way of cutting down the delivery time than in designing around commercial units. In this case less than 60 days elapsed between the start of the design and the delivery of the completed machine in the customer's plant, a feat impossible of accomplishment without heavy expense if parts were made special. It also permits the designer to give his major attention to the actual problem of the intended accomplishment of the machine, and still have the assurance that the details, including parts and units, will function properly and withstand severe service.



CROSS-SECTION of the tape guide. The ball bearings are pressed into the machine-steel spool. The 1¼-in. steel ball was drilled and tapped to receive the spindle

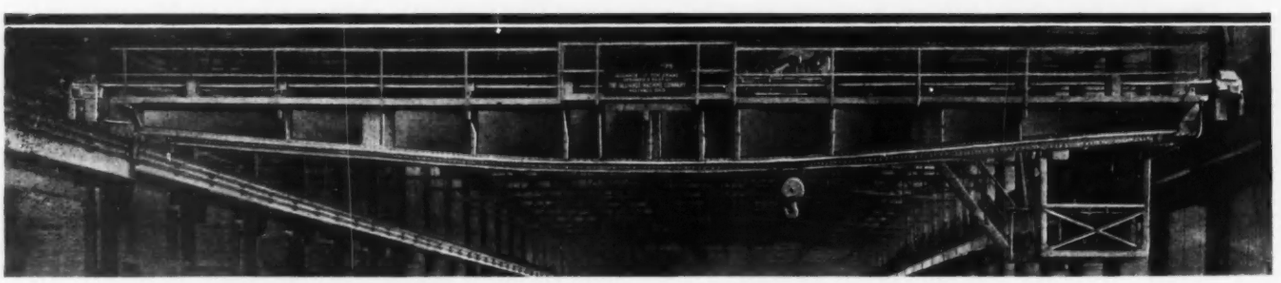
Following the Design Through

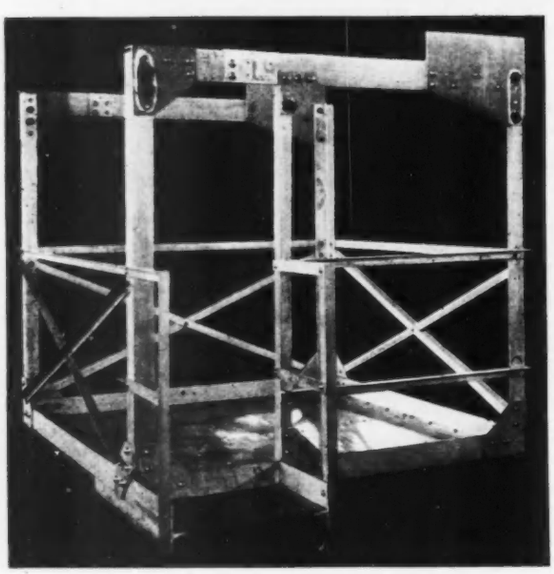
By F. M. Williamson
Nashville Bridge Company

THE designer should, if he does not do so, consider his design from a fabricating point of view, and be able to picture in his mind how the assembled product will appear when completed. It seems that we engineers are inclined to be mechanical. With a slide rule we solve the simple things instead of using common sense for small things and substantial reasoning for the more difficult problems.

When work is taken on designs made by others the chief draftsman should have a clear understanding of what is wanted before it is given to the drafting room for the detail drawings. If any further information is wanted he should make note of it and see that it is obtained. I have seen designs where changes were necessary for fabrication in the shop or assembly in the field. It is obvious what this means. A change in design here or there if not closely followed through means time and material wasted in the drawing room and perhaps in the shop. The only real solution is the maintenance of contact with the shop.

An effective way for the engineering force to keep in close contact is to have a meeting of the chief engineer, chief draftsman, squad bosses, and checkers as often as the particular business requires, to discuss work at hand. If any changes in the parts are contemplated all will then have the same understanding.



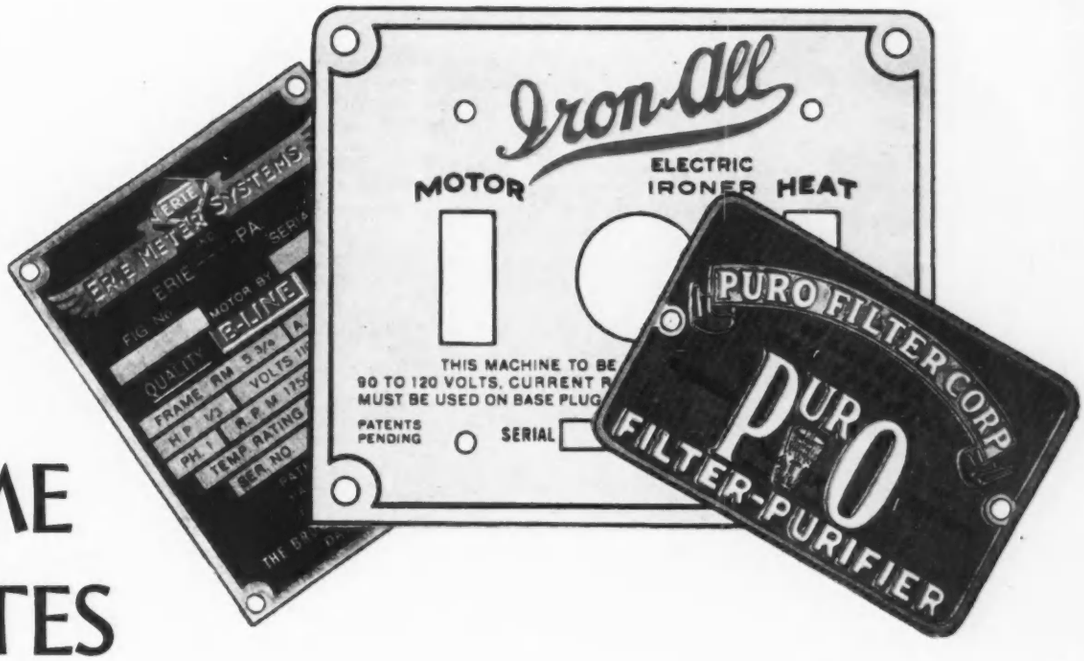


REDESIGN FOR LIGHT WEIGHT

By F. V. and E. C. HARTMANN
Aluminum Research Laboratories, Aluminum Company of America

THE aluminum-alloy 10-ton traveling crane shown is a 3-motor, single hook machine with a lift of 22 ft. Instead of the customary steel the bridge is fabricated from two double web girders spaced 7 ft. on centers. The girders are constructed of the strong aluminum alloys, and have a span of 72 ft. 2 in. Aluminum was also used in the walkway, handrails and operator's cage. The bridge girders frame into cast-steel carriages at their ends.

The crane was built by the Alliance Machine Company. Although this company had had no previous experience with aluminum alloys, it encountered no fabrication difficulties. The web and cover plates were flattened and sheared on the same equipment used in the construction of steel girders. A total of 12 tons was saved in the aluminum alloy crane, mostly in the girders, the total weight being 67,000 lb. A corresponding reduction can be made in the supporting members through the whole length of the runway. The light weight of the crane also permits a saving in power owing to the smaller inertia to be overcome in starting and stopping.



NAME PLATES

the finishing touch to the product

By FRED WEINDEL, JR.

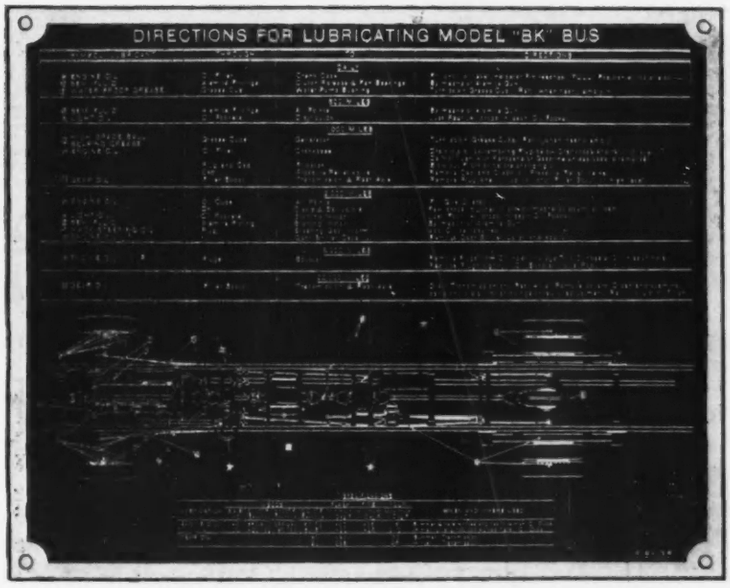
President, L. F. Grammes & Sons, Inc.

THE ARTIST who labors with palette and pigments to get the desired effect, is happy when the canvas finally breathes forth the subject of his dream, but he is happiest when he can add "his signature" to a work well done. This spirit of pride in one's handicraft is innate with all humans. The marker typifies that spirit, and the use of such markers has come to us—down through the ages from the time that Sargon, King of Akkad, ordered each brick to be stamped with his mark, and King Tut-anhk-amen caused metal plates to be attached to his belongings.

In industry great skill is frequently displayed in the creation, design, and manufacture of products of distinctive merit. Great care is exercised in all details of mechanical construction and physical appearances, yet unlike the Kings of old or the artist, too little thought is given to the opportunity for and the value of "a marker of distinction" by which men shall know the maker of the product.

Millions of dollars are spent annually in advertising to make people conscious of certain names and trademarks, so that the great mass of people, by far the largest percentage of consumer buyers, have come to recognize the names and trademarks of noted leaders in industry. Their "identification markers" when applied to their products tie in with the advertising, and are to these consumers an assurance of genuine craftsmanship and the promise of worthy products. This is true, whether the product be a radio or washing machine, vacuum cleaner or water filter, beds or stoves, watches or adding machines, motor trucks or printing presses.

There is no material that so ad-

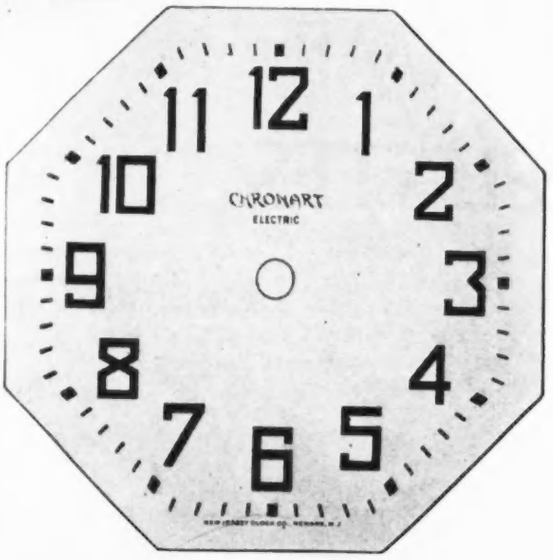


ETCHED PLATES are well adapted to furnish needed data throughout the life of the product

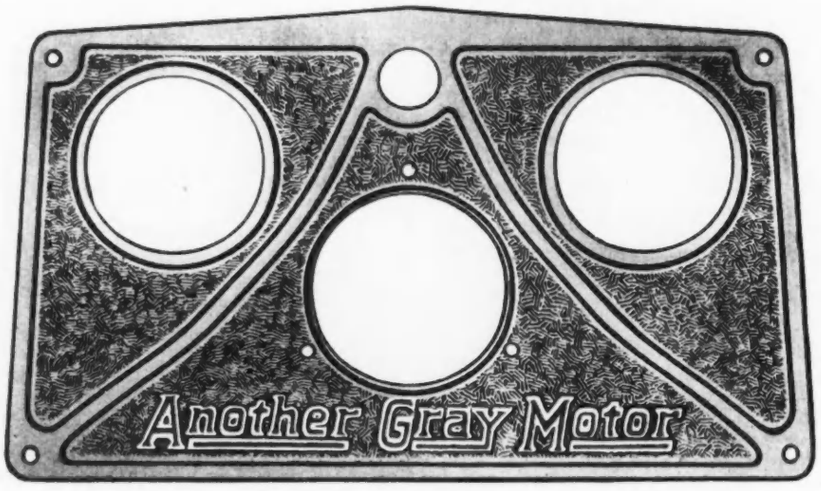
VITREOUS ENAMEL is used on this engine nameplate where resistance to weathering is wanted

THIS ETCHED and enameled plate gives data in a neat and effective manner

mirably lends itself for lasting use as an identification marker as metal. It can be cast, as were the ornaments of prehistoric man, stamped and embossed after the manner of the repousse work of ancient times, engraved like the famous swords of Damascus, enameled after the formulas of the goldsmiths of old, etched or lithographed as if by some of the greatest artists of all times.



ORNAMENTAL PARTS such as clock faces and panel plates may serve as the nameplate, and combine the signature with utility. However, the work of design requires the hand of an artist to make them fit the product



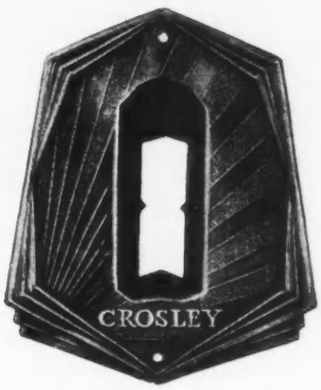
WHEN VIEWED from the standpoint of the complete cost of the product to which the name plate is attached, the name plate may be considered as inexpensive, but no designer can afford to class it as trifling. It is the distinguishing mark of the builder, and the company's individuality is there expressed as in no other part. On the factor of appearance alone the plate can give an impression of appropriateness or inappropriateness that might easily affect the sale value of the product, depending upon whether or not the designer of the plate has expressed the intention of the product in his work. There are five general classes into one of which the particular job will fall. These classes may be summed up as follows:

1. It may be expected to do nothing more than designate the trade name of the product.
2. It may be desired only to give the name and address of the maker of the product.
3. It may be required to give serial number, design number, patent number, specifications, and other informative data in addition to the signature of the maker.
4. It may be a chart plate with instructions and printed matter required permanently with the product, such as "lubrication data," "directions for use," diagrammatic reproduction of parts, or of equipment.
5. It may be incorporated into an escutcheon plate to give an artistic effect or to serve certain mechanical functions.

When one considers the almost infinite variety that can be produced in even the ordinary name plate by combinations of different metals, sizes, shapes, plating, embossing, enameling, and theme designs, the claims is readily understandable that the designing of name plates to best fit the needs of a given product is an art requiring long years of study and experience. A responsible name plate manufacturer hesitates to accept a job of making plates without knowing the ultimate circumstances of its use.

CUT-OUT PLATES are blanked from metal and finished by plating or enameling

THE ESCUTCHEON PLATE of a radio is an example of utility and beauty combined into the company nameplate



A NAMEPLATE can reflect the spirit of the product in its design, its finish, or its wording

THE CUPPED nameplate at the left is applied by forcing into a round depression. The plate below is of thin metal gummed

He must place himself both in the position of the designer of the product and of the user. The design should be characteristic if possible, and preferably there should be a standard theme expressed in the name plate for all of the firm's products. The name plate, therefore, cannot be considered as a part alone, but must be viewed as functioning with the product.

Due emphasis must be given to such factors as whether the plate shall be:

(*a*) Large or small.
(*b*) Rectangular, square, round, oval or odd shaped.
(*c*) Light or heavy gage.
(*d*) Of brass, copper, aluminum, bronze, nickel-silver, steel, or black iron.
(*e*) Embellished with ornate or simple designs, or designs characteristic of the type or use of the product.
(*f*) Flat or formed.
(*g*) For attaching with escutcheon pins, screws, prongs, glue.
(*h*) Nickel plated, chromium plated, copper plated, silver plated, oxidized, or relieved.
(*i*) In a finish entirely of the natural metal or having two, three or more colors.

Once the main idea of the name plate design is determined upon, there remains to decide the most effective manner of bringing it out on the plate.

Etching as a process for the transference of design on metals has been a fine art for centuries, but it is only within the last fifty years that it has been adopted commercially. Today, because of specialized factory methods, designs can be obtained on the product name plate for small cost that would have been considered high-priced works of art only a few years ago. By the etching process parts of the metal is eaten away chemically (actually only to a depth of 0.001 to 0.005 inches) so that the design is either raised or sunken, as desired. The sharpness of outline obtained by the proper use of etching solutions, and the contrast that can be obtained by clever use of plating and enamels, make it possible to obtain beautiful effects that are very durable in service.

STAMPED or embossed plates are produced by die stamping, and these likewise can be made in raised or depressed effects, with various combinations of plating or enameling. By no other method can we obtain such beautiful effects in bas-relief. Vitreous enamels are more costly than ordinary enamel or plated jobs, but are called for where the plate is desired to continue as a fine distinguishing mark even after exposure to severe conditions. Cut-out plates, used frequently for automotive vehicles, are blanked from metal and finished by plating or spraying with enamel.

Printing in one or two colors is much more simple in production than etching, but as the number of colors increases, the process becomes highly specialized (then termed lithographing) and requires highly skilled workmen both in development and in printing. The lithographed name plate combines color with economical production. Its use is more general for advertising signs, product containers, and display stands.

CONTINUED ON PAGE 183

COMMENT AND SUGGESTION

Belts on Small Pulleys

By George A. Rhoads
J. E. Rhoads & Sons

PULLEYS of too small diameter are a great source of trouble to the belt user. Slippage is much greater with small pulleys than with large, which means less output. Belts are more likely to open up at laps and between plies when pulleys are small. Again, there is lost time in take-ups, shorter life for belts and more wear on bearings. In fact, many manufacturers "Save at the spigot and lose at the bung" by trying to save in first cost of equipment. It is like working an employee 16 hours a day instead of 8 hours; he can't keep it up and deliver the goods.

Use large diameter pulleys and increase output and decrease worry.

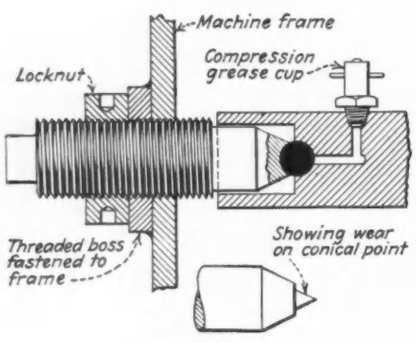
■

A Ball-Seat Pivot Bearing

By John Dan
Mechanical Engineer

IN THE February number P. H. White described and illustrated a type of conical pivot bearing adaptable for the shaft of a ¼-hp. belt-driven ventilating fan. I have used a similar design of pivot bearing for about twenty years.

As shown in the illustration a ball



seat is machined into the point of the conical pivot, and a corresponding seat is machined into the shaft. A ground steel ball mates with the seat in the shaft and with that in the pivot.

The advantages of this design over a plain conical point are less friction and less wear. With a straight conical point the surface of the cone in contact with the shaft will wear down, forming a shoulder, as shown in the sketch. The ball seat construction does not have this disadvantage and is therefore better.

■

STOP... LOOK... LISTEN...

•

. . . FATIGUE AGAIN . . .

FATIGUE in metals got another "final argument" in a paper at the Institution of Engineers and Shipbuilders (England), when R. A. MacGregor, who gave the paper, did some hard hitting at those who believe fatigue is the result of coarse crystallization from repeated overstressing. His own theory is that fatigue is purely mechanical. The play on words around this subject has been going on for years. While the argument goes on, it's still a good thing to recommend heat-treating bolts, rods, and parts that have been subjected to repeated stresses.

•

. . . STRAIGHT UP . . .

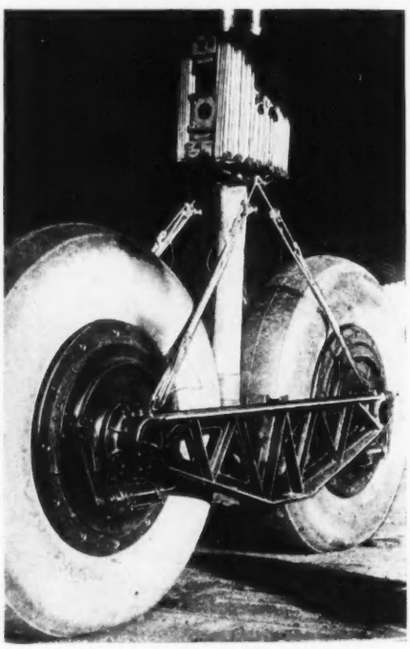
NO SOONER have engineers developed an airplane that can be flown with reasonable safety by a person having ordinary presence of mind and no more training than is required in learning to drive an automobile, than word reaches us of another advance toward safety in flying. This, we understand, is a combined helicopter and airplane capable of rising and descending vertically and of horizontal flight at 70 m.p.h. This craft is not one of those wild ideas of inventors with more imagination than practical knowledge of aerodynamics, but the sober and well-considered child of experienced product engineers, who are the brains behind one of our leading aircraft manufacturers. These men know how to build machines with a lifting power enough greater than their own weight to possess practical value.

Next in order, no doubt, is a pocket glider, which, in the event that his craft becomes stalled a few thousand feet up, will enable the aviator to toddle off to the nearest hangar and get a service plant to take his balky craft in tow!

Heavy-Type Landing Gear Design

By C. O. Wittmann
Engineer, Charlottenburg, Germany

THE UNDERCARRIAGE of the new Junkers G38 airplane shows a most interesting structural solution, quite a departure from the usual forms. The weight of the plane, which is the largest constructed, is 28,600 lb. empty, or a maximum of 53,000 lb. with full fuel load and



Junkers G38 undercarriage showing pivoted wheels, air brakes, and compression cords

passengers. In order to keep the specific surface pressure of the wheels on the ground within reasonable limits, a transition to a multiple-wheeled undercarriage could, therefore, not be avoided. It was thought better not to copy any of the usual four-wheeled carriages with two wheels side by side, and this led to the development of the undercarriage illustrated.

The carriage consists of two independent parts, which swing vertically on a longitudinal axle. This swinging is restricted by shock absorbing devices. The wheels are arranged in a pivot frame, suspended from the fuselage by three jointed struts, and

arranged to swing on a horizontal axle so that both wheels are subjected to the same stress when on unequal ground or when one tire is damaged. In taxiing, the bumping and jumping is almost overcome by this arrangement.

The wheels are fitted with Knorr air brakes, so that the airplane can be steered and stopped within a short distance. The Junkers G38 has a span of 148 ft., a length of 75 ft. A useful load of 6,600 lb. can be carried.

■

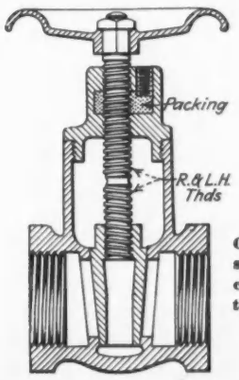
A Gate Valve Design

By P. J. McCullough

THE GATE VALVE shown is a modified form of a standard type of valve in which the wedge-shaped gate is threaded to take the valve stem, which in the original valve is threaded on the lower end only and is held in position against vertical movement by a collar integral with the stem.

The integral collar has been dispensed with to permit the stem to move up or down through the bonnet and packing. The upper portion of the stem is threaded right hand, and the lower portion left hand, therefore, the gate will fully open or close with a fewer number of turns of the stem than in a valve with a single thread and a collar. This right- and left-hand thread arrangement is in effect the same as a double thread except that the angle of repose is in its favor. This construction also eliminates the packing gland, or follower, and the packing nut, which are required in the conventional type of valve.

The packing is inserted at the threaded hole, near to and parallel with the valve stem, and is compressed with the hollow-head screw. Little force is required at the wrench or screw driver to compress the packing to the required maximum pressure against the threads of the valve stem. Unlike the ordinary type of valve, tightening or adjusting the packing does not change the amount of sealing surface or contact between the packing and valve stem. The valve stem threads are well lubricated at all times by the packing.



Gate valve in which sealing surface is constant, and few turns are required for adjustment

. . . NEW DRESSES FOR OLD CARS . . .

THAT old gag about the engineer who hailed a friend just leaving a smart looking motor car at the curb with the question: "New car, Old Top?" and received the prompt reply: "No! New top, old car," may be heard more frequently in the future if an idea, emanating from another engineer we know, should take root and bear fruit. This wide-awake individual believes that the motoring public is getting somewhat fed up on the prevailing custom of frequent changes in automobile body models that tend to make cars look out of date long before their mechanisms have worn out. To avoid this, he suggests that the automobile manufacturer might furnish new body shells, which, because they could be produced cheaply in large quantities, could be sold at the cost of a good refinishing job.

•

. . . FORCED RESEARCH . . .

APPARENTLY some of the automobile manufacturers are having a "big time" making wheel-spokes, radiator shells, hub caps, and other parts out of the so-called stainless steels. Also, the reaction keeps coming in from the jobbing shops that have accepted contracts to make some of these parts without previous experience with the chromium steels. Some money may be lost by some, but in the long run it looks like a fine thing for the industry in general. We are going to learn how to draw and work these alloys in a mighty short space of time!

•

. . . LIGHT DIESEL ENGINES . . .

ACCORDING to O. D. Treiber, who presented a paper at the annual meeting of the S.A.E., there is a decided trend toward light weight in Diesel engines. The needs of the motorcoach and motor truck services in Europe led to some quite satisfactory designs. In this country a line of engines that weighs 15 to 20 lb. per hp., running at speeds of 1,000 to 1,200 r.p.m., have been developed. Some design features are: camshaft mounted in the cylinder head, inlet and exhaust valves pocketed into the cylinder liner, heads separate from the cylinders, electric motor starter with compression-relief to reduce starting torque.

•

. . . COLORED LOCOMOTIVES . . .

"HOW the old town do change!" said the sailor after his long voyage. It wasn't many years ago when our Northern peoples laughed with derision at bright colors. Yellow was the banner of a backward nation, and any girl who came down the street wearing a bright-colored dress was likely to be dubbed as a "wop." Now, not only have all kinds of manufactured products been decked out in fancy colors, but even the railroads have adorned their trains. Witness the "Blue Comet" of the New Jersey Central, and the red and gold "Senator" of the Pennsylvania, and others! Light-colored cars mean clean cars as well as pleasing-looking cars, they say, and we agree with them.

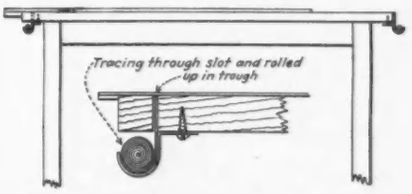
■

Long Tracings

By Morton Schwam

Design Draftsman, Naval Aircraft Factory

WHEN A LONG TRACING must be handled upon a relatively short drawing-board, the tracing can be kept off the floor and handled conveniently by preparing the board in accordance with the accompanying sketch.



Drawing board arranged to accommodate a long tracing

A $\frac{1}{8}$-in. slot, slightly longer than the width of the tracing, is cut in the board close to the T-square edge. When the draftsman completes the part of the drawing that can be accommodated on the board, he simply draws the tracing through the slot, rolling it up in the trough provided on the under side of the board to keep the tracing off the floor. A similar trough can be placed on the right end of the board to hold the unfinished part of the tracing. If a parallel straight edge is used in place of the conventional T-square, the slot in the board is not required, but the troughs can be placed at each end of the board in a like manner.

■

How Long Should Records Be Preserved?

C. Norman Fletcher

Director, Edward G. Herbert, Ltd., Manchester, England

IN ENGLAND the "Statute of Limitations" applies after seven years, and therefore it seems unnecessary to keep ordinary correspondence longer than ten years at the outside. But records!—Well they are different. Weiss was somewhat off the handle when he quoted mail order procedure,

it must be remembered that such businesses almost invariably sell standard articles which can be taken off the shelf and for which they have a potential customer in every home, and further, they deal largely with individuals. In consequence, for a given amount of business a large percentage of their customers are ephemeral. Engineering is much more restricted in its field, and business connections established between companies are more likely to lead to a recurrence of orders even if only at comparatively long intervals.

This being so, records are necessary. They may be, and in fact should be, simple and concise. A card index containing brief particulars of all quotations made and orders received can be entered readily from day to day, and if each company is given a separate card, it will be found that such a record becomes invaluable as the years pass by.

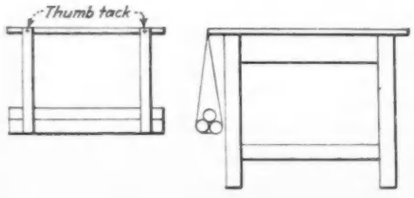
The possession of such a record renders the retention of really old order books unnecessary, and is a valuable safeguard when questions about matters over the ten year limit arise. Even when making special machinery it seems unnecessary to keep correspondence more than ten years if the system suggested is followed, for no machinery lasts forever. When repairs are necessary to such old equipment an inspection of the old, worn out or broken pieces will usually provide sufficient data to enable the job to be done.

■

A Handy Drawing Rack

By George A. Fries

THE SKETCH ILLUSTRATES A RACK supporting rolled drawings and layouts, hanging from the side of the drawing board. In many drafting rooms the draftsman is furnished a reference table beside his board, and in some cases the table has no drawers. So, rather than have these drawings and layouts lying on top of the table and giving the room an untidy appearance, two strips of heavy paper or tracing cloth approximately 2-in. wide, the length to suit, are hung from the end of the drawing board to form two straps. The rolled layouts and drawings are shown in place in the sketch.



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Interchangeable Flange Mountings and Belt Drives

By L. J. Radermacher

Chief Engineer,
Kempsmith Manufacturing Company

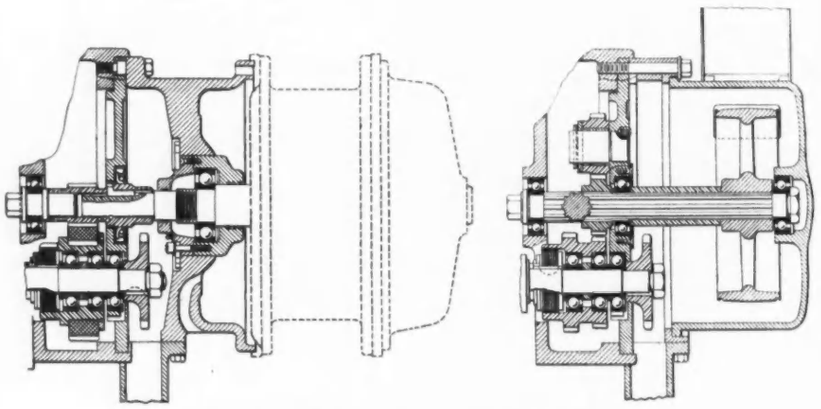
IN THE ARTICLE "Flange or Foot Mounted Motors?" in the February number of *Product Engineering*, the question was raised regarding the furnishing of machine tools with flange-mounted motors when some customers require a belt drive rather than the standard motor drive.

In our milling machine we believe we have solved this problem in a manner that is quite practical for the manufacturer who mounts the motors on the machines in his own shop. In this case we have milling machines in which we use the motor also as a reversing mechanism, furnishing a reversing switch with the electric equipment on each machine. For the purpose of securing compactness we use high speed motors, that is, 1,500 or 1,800 r.p.m. When a single pulley is required, we have a pulley unit that goes on the machine in place of the motor and also incorporates the reversing mechanism for the spindle drive. The pulley speed is 900 r.p.m.

All columns are bored the same. The only change being in assembly, at which time we mount a motor or pulley and reverse gear as required. The two units and their mounting are shown in an accompanying illustration.

While we expected some difficulty when this design was developed because of the number of different motor bases that might be required, we have, to date, been able to get away with a very limited number of bases by the simple expedient of expressing our preference for a particular motor, but at the same time stating our willingness to furnish any motor the customer requests. The number of non-preferred motors has been surprisingly low, approximately 10 per cent.

Now that the manufacturers are adopting standard base and shaft dimensions it is not too much to hope that they also will develop standards for flange mounting that will be equally convenient and adaptable and which will render the mounting of motors much more economical and efficient.



Sectional views of flange mounting and interchangeable belt drive unit on a Kempsmith milling machine

■

Checking Drawings

By F. B. Hart

IN AN article in the February number of *Product Engineering* Mr. Matthews suggests that the checker make a thorough check of the drawing but put no marks other than a circle, in yellow pencil, around the dimension that he thinks wrong. Several drafting rooms where I have been employed used this plan, but in my estimation the following system used by a well-known aircraft factory is far better.

The checker uses three colored pencils, red, yellow, and green. The red pencil signifies errors to be corrected or changes to be made. The yellow pencil marks the data and dimensions that are correct, and the green pencil checks all information that is in doubt to the checker, meaning he would like to question the detailer. When the detailer receives

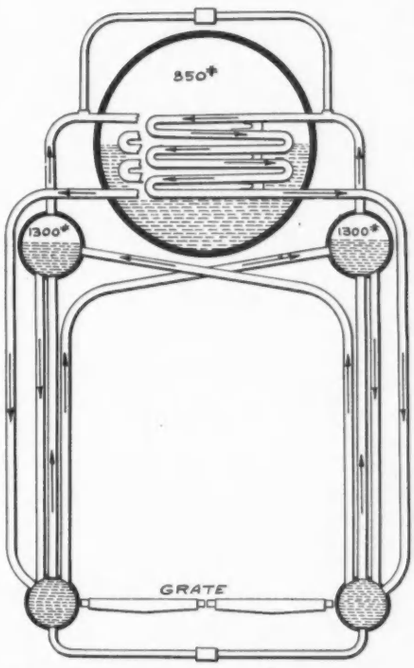
this marked print, he makes the corrections and changes, and returns the print to the checker for question of the green marks.

The feature of this method is that every dimension on the drawing gets a mark, and very rarely anything is overlooked. I might add that in many drafting rooms drawings are checked by marking the tracing itself. This is bad practice because many things are left to the checker's memory and often things are overlooked.

■

High-Pressure Locomotive Boiler Design

A HIGH PRESSURE, double pressure locomotive differing greatly from the present large modern freight engines will be built at the Augus Shops of the Canadian Pacific in co-operation with the American Locomotive Works. This new locomotive will make use of the indirect method of steam generation.

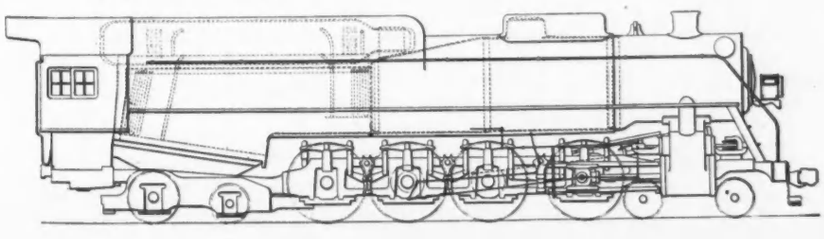


Firebox arrangement of high-pressure locomotive showing path of water and steam circulation

Pressure as high as 1,300 lb. per sq.in. is developed in a tube system exposed to the hot combustion gases. The tube system is filled with distilled water, and the generated steam rises into a coil in the high-pressure boiler. In this coil the steam is condensed, transferring its heat to the water in the boiler. The coil system is self-contained, and the quantity of water in it remains unchanged.

The high-pressure drum is not exposed to the direct radiation nor to the high-combustion temperatures. The steam at 850 lb. pressure is used in one high-pressure cylinder, and steam at 250 lb. is generated in a normal fire-tube boiler and is then supplied to two low-pressure cylinders. The high-pressure system occupies the place of the firebox of any ordinary locomotive. The locomotive is expected to be from 20 to 30 per cent more economical than the usual type of locomotive.

Diagram of high-pressure locomotive showing position of tube system



The Finishing Touch to the Product

CONTINUED FROM PAGE 179

To illustrate the negative influence of improper application of a plate, a case can be cited: It is an example of a very beautiful waffle iron. The general design and efficiency of this waffle iron is good, and it has a beautiful chromium plated finish. Yet, to tell who made it, what voltage to use and the serial number, a plate, made of brass, unpolished, etched, having a black background, rectangular in shape and having sharp corners, has been used. To attach this plate, two heavy, large headed screws (chromium plated) have been used. This plate has a decidedly unfavorable appeal.

Now, consider a case for the positive influence a plate may create: Recently a manufacturer of small electrical appliances designed a new and distinctive character in an electric iron. In the development of design the manufacturer called a specialist into conference. It was desirable to attach a plate to this iron, but he was puzzled as to what kind, or where to attach it. The designers of the nameplate specialist were given the problem to study. They noted:

1. That the new iron possessed a distinctive shape.
2. That it had decided modernistic lines.
3. That it was chromium plated and had a bright colored handle.
4. That because of the heat factor, the plate used would have to be heat resisting. In other words, the finish had to withstand considerable heat.
5. That there was definitely one best place to attach a plate, but it must be truly artistic in design and made to be in harmony with the rest of the design.
6. That this iron was to be sold at a popular price, and therefore it was important that the cost of the plate be kept to a minimum.

The plate recommended and accepted was made of aluminum specially finished to be in tone harmony with the balance of the iron. It was odd shaped, to fit a special place on the iron. It was made with prongs for attaching. Its face design not only included all pertinent matter, but had a modernistic theme etched on the background. Thus, the iron and the plate formed a harmonious whole.

The entire subject of name plates for the product falls under what has been aptly called by our company Metal Print Craft. It is the fine art of reproducing wording, design, and ornamentation of metals by various specialized processes. But product name plates also involve something more—that is, the visualization of the product in a comprehensive way, and the bringing into the name plate the aims of the product designer and the distinguishing characteristic of the product manufacturer.

STRESSES

in symmetrical tubes

By GEORGE F. NORDENHOLT
Associate Editor

FUNDAMENTAL EQUATIONS for analyzing stresses in the walls of tubes of symmetrical cross-section subjected to internal pressure. A comprehensive presentation of Castigliano's theorem, the basis of this analysis, will be found in "Applied Elasticity" by Timoshenko and Lessells, Westinghouse Technical Night School Press

WHEN A LOAD is applied to an elastic body, the body deflects or yields. As long as the proportional limit is not exceeded, the strain or deflection will be proportional to the resisting stresses set up in the material, and when the load is taken off, the body returns to its original form. It can readily be seen that the work done on the body in applying a load P will be equal to the average load, $\frac{P}{2}$, times the strain. This is shown in the accompanying stress strain diagram, the work done being represented by the area under the stress-strain line, and being equal to $\frac{P}{2}$ times delta. If no permanent set results from the application of the load P, the same amount of energy, $\frac{P}{2}$ times δ will be given up by the body while the load is being taken off. The energy thus stored in a body under load is called the potential energy of deformation. The same principle applies whether the load be simple tension or compression, or whether it be shear or bending moments.

The letter U will be used to designate the potential energy of deformation. Referring again to the first figure, if an infinitely small load dP be added to the applied loads there will be a correspondingly small increase in deformation $d\delta$. The potential energy of deformation will be increased by the double cross-hatched area. Designating this increase of potential energy by dU, we have

$$dU = Pd\delta + \frac{dPd\delta}{2}$$

The second term of the right-hand member, involving the product of two infinitely small quantities, may be considered as being equal to zero. Hence,

$$dU = Pd\delta \qquad (1)$$

But from the similarity of triangles, OAB and BCE

$$\frac{d\delta}{dP} = \frac{\delta}{P}$$

Or

$$Pd\delta = \delta \cdot dP$$

Substituting this in equation (1) we get

$$dU = \delta \cdot dP$$

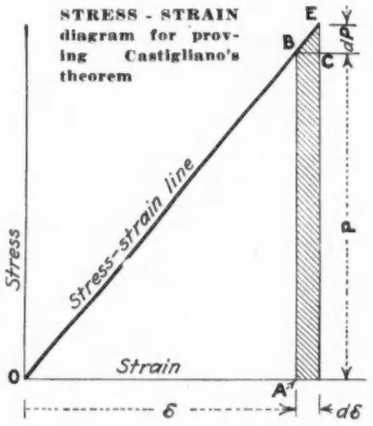
Hence

$$\frac{dU}{dP} = \delta$$

This equation is the mathematical expression of what is known as Castigliano's theorem. It applies whether the load be a force P or a bending moment M, and also when the stress-strain curve is not a straight line. The potential energy of deformation must, however, be expressed as a second degree equation, in order that this relationship hold true.

Castigliano's theorem has a direct application in analyzing the stresses in hollow tubes of symmetrical cross-section when subjected to internal pressure. Such constructions are represented by rectangular tubes in boiler-headers, non-circular symmetrical tanks or pressure ducts subjected to internal pressure, or reinforcing rings for such constructions.

The most general case is an oval shaped symmetrical ring, such as shown in the accompanying figure. The analysis for bending moments in a symmetrical ring of any shape is made in the same manner. On account of



the symmetry, there will not be any relative rotation of the two sections where the ring crosses the X and Y axes, that is δ equals 0 at these points in so far as bending is concerned.

Hence, applying Castigliano's theorem

$$\frac{dU}{dM} = 0$$

The general equation for the potential energy of bending in a beam is

$$U = \frac{M^2 l}{2EI}$$

where l is the length of the beam between the two sections under consideration, and M is the bending couple to which each section is subjected, the bending couples

being equivalent to the applied bending moment in so far as bending is concerned.

From this $$\frac{dU}{dM} = \frac{2Ml}{2EI} = \frac{Ml}{EI} = 0$$

or $$Ml = 0$$

In this symmetrical ring the value of M will be different at every section, Ml representing the sum of each value of M times the infinitely small length, ds, on which it is imposed. Evidently the summation of all the values of $M \cdot ds$ over the whole length of the quadrant of the ring will be represented by the integral of $M \cdot ds$ between the limits from 0 to l, that is,

$$\int_0^l M ds = 0 \qquad (2)$$

Taking a unit length of the tube of symmetrical shape it will be seen from the figure that for a uniform internal

COUPLES acting at sections of beam. They are equivalent to the applied bending moment

unit pressure the bending moment at any cross-section whose co-ordinates are x and y, will be, referring to the figure in the next column,

$$M = M_0 + M_1 + M_2 - M_3$$

M_0 is the bending moment at the X axis, M_1 equals the product of the unit pressure p times the projected area $(a - x)$, times the moment arm,

or $$M_1 = p(a-x)\frac{(a-x)}{2}.$$

Similarly $$M_2 = py \times \frac{y}{2}$$

And M_3 is simply the unit pressure p times the area a times its moment arm $(a - x)$.

As we are considering a unit length of tube, the values of the areas will be the same as their dimension in the cross-section.

The moment M at the point x,y will be:

$$M_0 + p(a-x)\frac{(a-x)}{2} + py \cdot \frac{y}{2} - pa(a-x) \qquad (3)$$

When multiplied out this equation reduces to

$$M = M_0 - \frac{pa^2}{2} + \frac{px^2}{2} + \frac{py^2}{2} \qquad (4)$$

Substituting equation 4 in equation 2, we get

$$\int_0^l \left[M_0 - \frac{pa^2}{2} + \frac{px^2}{2} + \frac{py^2}{2}\right] ds = 0$$

Integrating the first two terms of this expression, knowing that the integral of ds is s, and substituting the limit l for s, we get

$$\left(M_0 - \frac{pa^2}{2}\right) l + \frac{p}{2}\int_0^l x^2 ds + \frac{p}{2}\int_0^l y^2 ds = 0 \qquad (5)$$

Now the summation of the product of each differential length times the square of its distance from the axis is called the moment of inertia.

Thus the expression $\int_0^l x^2 ds$

is the moment of inertia of the line of the quadrant of the ring, about the Y axis and may be designated by I_y.

Similarly $$\int_0^l y^2 ds$$

is the moment of inertia about the X axis, and may be designated by I_x. Hence, equation (5) may be written

$$\left(M_0 - \frac{pa^2}{2}\right) l + \frac{p}{2}(I_x + I_y) = 0$$

or $$M_0 = \frac{pa^2}{2} - \frac{p}{2l}(I_x + I_y) \qquad (6)$$

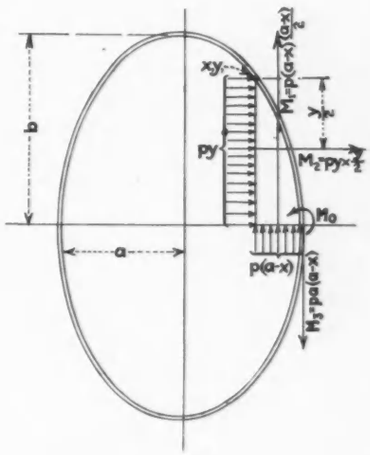
From this last equation, the value of the bending moment at the plane where the X axis of symmetry crosses the ring, can readily be calculated. Knowing the value of M_0, equation 4 may readily be solved to obtain M for any value of x and y.

The above equation 6 is general, and may be applied to any shape of symmetrical ring, rectangular or otherwise. Probably the most familiar shape of symmetrical ring is the circle. Because of its complete symmetry there are no bending moments set up by a uniform internal pressure in a circular tube or cylinder, neglecting end conditions.

Applying equation 6 to this condition, wherein a is equal to r, the radius of the circle:

$$M_0 = \frac{pr^2}{2} - \frac{p}{2l}(I_x + I_y) \qquad (6)$$

SYMMETRICAL RING subjected to uniform internal pressure



For the quadrant of the circle,

$$I_x + I_y = \frac{\pi r^3}{2}$$

As the circumference of the quadrant of a circle is $\frac{\pi r}{2}$ we get $$2l = \pi r$$

Substituting these values in equation 7,

$$M_0 = \frac{pr^2}{2} - \frac{p}{\pi r} \times \frac{\pi r^3}{2} = \frac{pr^2}{2} - \frac{pr^2}{2} = 0$$

This merely bears out the fact that there are no bending moments set up by internal pressure in a perfectly cylindrical shell, neglecting end conditions.

In the next article examples will be given showing how, by the application of these equations to tubes whose cross-sections are hollow rectangles, the bending moments and stresses in such tubes may be calculated.

PRODUCT ENGINEERING

Editor: KENNETH H. CONDIT

April, 1930

> ***. . . . . and Engineering not dully or prosaically, but with imagination, interpretation, lucidity, and a sense of beauty . . . .***
> —M.I.T. *Technology Review.*

More Engineering—More Profit

ONCE upon a time men were largely industrially independent of each other. Homespun clothes were made and dyed in their own homes; shoes were pegged in spare time; candles were made by the children; soap came from the pan grease and the fireplace ashes. But, while the advantages of specialization and large-scale production of such things are now obvious, aren't many designers still making colonial homes out of their plants?

In another section of this number of *Product Engineering* there is an admirable example of a design of a special machine in which the designer turned the time of his own shop to the major problem of producing a machine to do effectively a given job. He called for as few parts to be made in his shop as possible, accepting the proved units of specialized manufacturers to accomplish the requirements of the detailed mechanisms of the machine. But it is not only to the special machinery builder that this applies. Recently, a large machine-tool manufacturer was found making his own bolts within a "stone's throw" of another plant where he could have purchased more accurate bolts of better steel at a lower cost. It may be self-satisfaction to have a large force of workmen making everything in the product, but economically it is much better to have *more designers with knowledge* of commercial units and *more profit per workman* in the plant.

Who Should Design the Package?

THE PRODUCT has not met sales requirements until it has been delivered into the hands of the user in perfect condition. This may be such a truism that it is silly, but nevertheless there are apparently many designers who are leaving it up to the sales, production, or to a very indefinite shipping department to arrange for the package which is to safeguard the carefully-made product on its rough journey to the consumer.

Actually, the means that will be used in shipping the product should be considered in making the design itself. Sometimes, by making legs or projecting parts demountable, space can be saved and stability assured. There have been examples of heavy machines designed that would not pass through tunnels on the railroads, where slight changes in the frame would have solved the difficulty. In other cases lugs and supports would have greatly reduced the danger of breakage in shipment.

In small products, particularly, the designer should give thought to the package. For such products it might well be said that the package is part of the product. He should study it from the various angles of resistance to impact, protection of surfaces, and protection against the weather. If he is interested in the product from start to finish he cannot well ignore the package.

■

Time for Motor Standards

SO LONG AS machinery manufacturers are willing to take electric motors with a needless diversity of mounting dimensions and build special brackets to adapt these motors to their requirements, just so long will the present lack of standardization in these respects continue to pile up expense.

Many machine manufacturers realize the need for standardization, and have done so for years past. What appears to be lacking is a unified and determined effort to create standards that will be satisfactory to all concerned. Some steps toward certain dimensional standards in respect to a limited group of squirrel-cage induction motors have been initiated by the motor manufacturers, but even this effort has dragged along slowly.

Automobile manufacturers long ago adopted

standard mounting dimensions for electric starting motors and lighting generators. Today, this electrical equipment is supplied by specialists who make only automotive products, but when manufacturers of conventional motors made this class of product they willingly followed the automotive standard.

It was merely necessary for the automobile manufacturers to present a united demand for a standardized product to get what they wanted without paying a special price. Machinery manufacturers could accomplish a similar result by following the same method. The task is more complex, but it is quite possible of attainment. It is time for energetic action.

■

Motion Study and Machine Design

THE ONE-ARMED paper hanger whose troubles have long served as a picturesque symbol of activity seems to have many near relatives in industry, if we can judge from the number of production machines so designed that the operator cannot possibly use more than one or two of his four limbs. Motion study engineers in several of our large plants are beginning to complain that (1) the machinery with which they have to contend does not permit the operator to avail himself of the short cuts taught by motion study; (2) that their requests for better machines are not received with much enthusiasm by the machinery builders and designers.

It is important to take advantage of the best of modern materials in the design of a new machine. It is commendable to employ the highly developed standard units now available. It is essential to use one's greatest ingenuity in the application of mechanical movements. It is clever to design beauty into the machine. But the whole effect may be spoiled if the product is not so designed that the operator is given free rein to use his skill and speed to the utmost without undue fatigue.

The hard pressed designer may have thought he had almost enough contradictory factors to compromise, but a consideration of the principles of motion study is one more with which he must reckon if he is not already doing so.

Fifty Years of Engineering

THIS MONTH the American Society of Mechanical Engineers celebrated its fiftieth anniversary. No man can say exactly what part the mechanical engineer has had in the tremendously accelerated progress that has occurred since 1880. But no man can deny that this so-called machine age, the fundamentals of which have been created by the engineer, has brought better social conditions for the great masses than ever before.

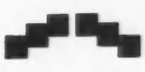
Much of the progress has been brought about by demands outside the sphere of the engineer. But he has risen to meet them, and most certainly one of the important factors in the tie-up has been the co-operation realized through this great Society. May it continue its course of guidance, inspiration, and research that has marked its successful life so far.

▼

New Designs for Old

FOOT RULES have been pretty well standardized for many years. They are made in vast quantities, in three, four, six, and eight feet lengths, and are used by all kinds of engineers, by architects, builders, and by the public at large. But did you ever notice the large percentage of those in use that are used *broken?* And the appropriate swear words when they are used?

Foot rules of any good make seldom or never break at the joints, which are of metal, with the pivots well headed over. But the rules are of wood, probably because they have always been of wood! Why not apply the tactics of ordinary machine design to the development of a better rule? The new aluminum alloys, for instance, are even lighter than wood, and about as strong as good steel. They can be etched or enameled, or chemically colored. Laminated molding resins, also, are lighter and stronger than wood. Some things can be done with them in the way of coloring, embossing, and printing that cannot be done with wood. Wouldn't the average engineer pay more for a rule that was always reliable on the job, and that unquestionably would look better?



NEW MATERIALS AND PARTS AND ✦ ENGINEERING EQUIPMENT ✦

"P.M.G." Metal—A Hardened Copper Alloy

AS A SUBSTITUTE for phosphor bronze, manganese bronze, and gun metal, "P.M.G." metal was developed by Messrs. Vickers-Armstrong, Ltd., Barrow-in-Furness, England. The material is now available in the United States through the Driver-Harris Company, Harrison, N. J. From the experience of the originators, this alloy is superior and can replace phosphor bronze on economic and practical grounds. It is claimed to be superior to manganese bronze, to 70/30 brass, and 9 per cent aluminum bronze for many applications. It is, in fact, a hardened copper alloy, which can be utilized where high tensile strength, considerable elongation, and resistance to abrasion are required.

"P.M.G." metal was originally intended as a substitute for Admiralty gun-metal, the standard composition of which is 88 copper, 10 tin and 2 zinc. The metal is a copper alloy, in which the 10 per cent tin is replaced by 10 per cent of a special hardener. In making the alloy, however, the addition of the hardener need not be confined to 10 per cent. The alloys investigated have had hardness contents ranging from 1 to 18 per cent and zinc from 0 to 40 per cent but the standard composition is as given above.

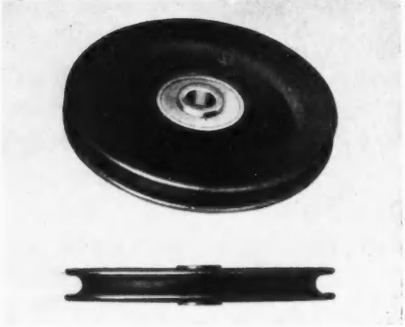
The alloy as cast contains as constituents 2 per cent of iron, 3.4 per cent of silicon, and 2 per cent of zinc. Hardening is due presumably to the presence of iron silicide. The properties can be modified by heat-treatment, consisting in quenching with or without reheating. Heated castings do not scale.

One group of sand cast bars had a yield point of 23,500 lb. per sq.in., ultimate stress of 47,500 lb. per sq.in., elongation of 10 per cent in 2 in., and a fine fracture, whereas on another test the yield point was 27,800 lb. per sq.in., ultimate stress, 49,300 lb. per sq.in.; elongation, 13 per cent in 2 in., and a grained fracture. The material can be forged hot readily without cracking. After forging to a black heat, the properties are as follows: yield point, 82,650 lb. per sq.in.; ultimate stress, 94,000 lb. per sq.in.; elongation, 17 per cent in 2 in.; and silky fracture. The metal does not become brittle even when the finishing temperature is very low. The Brinell hardness ranges from 104 as cast to 153 as forged.

■

General Electric Molded Ball-Bearing Pulleys

TEXTOLITE molded to shape around Norma-Hoffman ball bearings comprise the materials used in the pulleys announced by the General Electric Company, Schenectady, N. Y. The bearings employed are of the single-row, self-contained type. As originally developed, these pulleys are for use in control systems of aircraft and the standardized diameter is 3½ in., which is in accordance with the specifications of the U. S. Government. Doubtless there are many other applications of such an anti-friction pulley on delicate equipment having counterbalanced members. These particular pulleys have a ⅜-in. bore and weigh 3½ oz. each.



General Electric Molded Ball-Bearing Pulleys

Condit Type A-15 Air Motor Starter

ARC PREVENTION is the chief feature of the Type A-15 air motor starter announced by the Condit Electrical Manufacturing Corporation, Boston, Mass. The contacts, according to the manufacturer, are of such shape, mass, relation, and arrangement with respect to the voltage and the energy to be absorbed as to reduce the visual evidence of circuit interruption to a spark of negligible importance, even under heavy overloads. The starter contacts are assembled in units on insulated carrier bases, one stationary and the other movable.

Condit Type A-15 Air Motor Starter

The starter is simple and compact, and is inclosed in a steel case arranged with conduit knockouts. Thermal cutouts are provided for time-lag overload protection. The type A-15 air motor starter is furnished for 7½ hp. at 550 and 440 volts, 5 hp. at 220 volts, and 3 hp. at 110 volts.

■

Reliance Stainless Steel Lockwashers

STAINLESS STEEL for lockwashers has been perfected, according to an announcement by the Reliance Manufacturing Company, Massillon, Ohio. The company is

now prepared to furnish the trade with these lockwashers in any size or section. It is claimed that in addition to having all the qualities of a non-corrosive stainless steel, they are of a spring temper equal to that of the ordinary steel lockwasher. The steel is drawn by a special rolling process by which it is finished in a Brinell of sufficient hardness to produce the stiffness and reactive pressure necessary in a lockwasher, and makes subsequent heat-treating unnecessary. This company is also in a position to furnish the trade with stainless steel in coils or straightened and cut to length in any small section—round, flat, square or hexagon from 0.022 to $\frac{5}{16}$ inch.

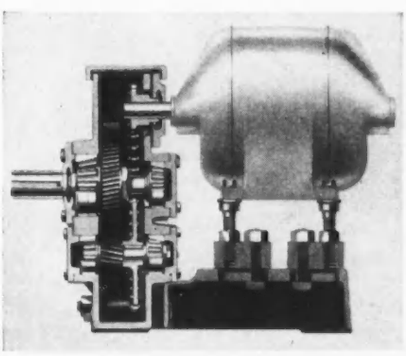
■

Cullman Improved Speed Reducer

IMPROVEMENTS have been made in the Cullman speed reducer manufactured by the Cullman Wheel Company, 1346 Altgeld St., Chicago, Ill. Chief among these is the substitution of Timken roller bearings for phosphor-bronze bearings. Another improvement is the use of helical gears in the place of spur gears.

On the Cullman reducer the first reduction is obtained by a chain and sprocket drive from 2 to 6 times below the motor speed. This not only cuts down gear wear, but also reduces noise. The gears are supported by four Timken bearings.

Changes have been made in the oiling arrangement at the main gear bearing and at the point where the motor shaft enters the case. At this latter point the hub of the sprocket has been extended into the oil chamber, replacing the ring previously used. A spray of oil is furnished at all points by the sprocket chain. At each bearing there is a circular recess with a bottom outlet, which provides complete drainage of the oil back into the interior of the reducer, thus preventing leakage. No change has been made in the over all dimensions.



Cullman Improved Speed Reducer, which is now equipped with Timken tapered roller bearings

■

"Alumilite" Protective Coating

AN ELECTROLYTIC method of applying a protective and decorative coating to aluminum and its alloys has recently been developed by the Metals Protection Corporation, 401 W. Michigan St., Indianapolis, Ind. The coating, known as "Alumilite," may be had in either a silvery white or in a variety of colors, including black and various shades of blue, yellow, red, brown, green, and purple. Since the coating is applied electrolytically, it becomes an integral part of the aluminum itself and will not crack, chip, nor peel off. Treated sheets may be stamped and formed without marring the finish.

According to the manufacturer, properties of this coating are as follows: Alumilite offers unusual resistance to atmospheric and salt water corrosion and samples subjected to the salt spray test show perfect resistance after 3,000 hours. The coating in almost all colors is not affected by hot water or steam.

Tests show that an Alumilite coating has more resistance to wear than a heavy nickel plate. It will not withstand cutting by a sharp pointed instrument, but does offer considerable resistance to same. A blunt instrument, on the other hand, will force the coating into the softer metal beneath without rupturing it. Measurements made by the Bierbaum apparatus indicate that the coating has a hardness equivalent to that of a medium hard steel.

Since Alumilite itself is hard and does not tarnish, it will not injure or discolor other articles with which it comes in contact. The treated aluminum surface will absorb certain lacquers as well as oil. It is therefore a good base for such materials, which provide added resistance to corrosion and abrasion.

Since the process of applying Alumilite is an electrolytic one, there is no application of heat in the process higher than 212 deg. F., and hence there can be no annealing or warping of the base metal. Almost the same apparatus as is used in nickel or copper plating is suitable for the process. The plating time varies from 5 to 40 min., depending upon the thickness of coating desired.

The field of application of this coating is very wide when used for purely decorative purposes. When advantage is taken of its corrosion-resistant properties, it is found suitable for motor boats, marine fittings, optical, electrical and similar instruments, and airplane parts such as propellers, motor castings, struts, and sheets.

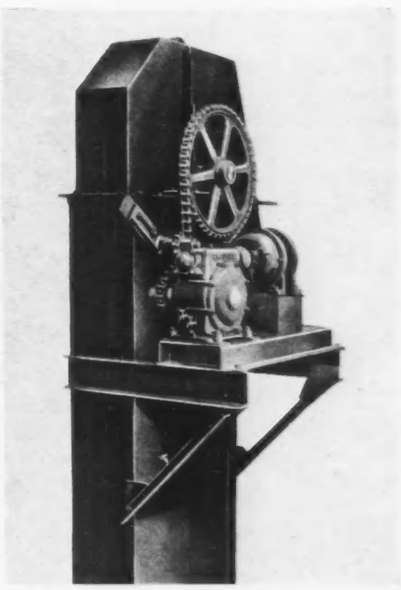
■

Caldwell Standardized Elevator Drive for Bucket Elevators

A WORM GEAR reducing unit comprises the drive for bucket elevators announced by the H. W. Caldwell & Sons Company, subsidiary of the Link-Belt Company, 2410 West 18th St., Chicago, Ill. This drive is suitable for application to centrifugal discharge, perfect discharge, or continuous bucket type elevators requiring from 3 to 15 hp. The entire line is standardized and carried in stock.

The motor and the worm reducer are accurately aligned on a welded steel base, making a compact assembly, easily supported on the elevator casing or platform. The worm gear reducer unit has a hardened and ground steel worm, and a special bronze worm gear. A flexible coupling connects the reducer to the motor. All bearings are of the anti-friction type. A splash system lubricates all moving parts.

The welded steel base is made to fit the installation. Some bases are



Caldwell Standardized Worm Gear Reducer Unit mounted on a vertical centrifugal discharge bucket elevator

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furnished with extensions at the motor end to span the full width of the casing, so as to be mounted on the projecting platform beams, while others are mounted directly on such platforms, walkway or other support.

The second reduction in speed is made by a Link-Belt "RC" Class roller chain, engaging with the cut steel pinion on the worm gear shaft, and with a cut cast-iron sprocket on the elevator head shaft.

The Caldwell drive units are divided into two groups of 3- and 5-hp. series, using a No. 1 reducer, and a 7½-, 10-, and 15-hp. series, using a No. 2 reducer. Each group is further divided into two series: one for slow moving continuous and perfect discharge elevators, with head shaft speeds of 15 to 23 r.p.m., and the other for centrifugal discharge elevators having head shaft speeds of 35 to 43 r.p.m. Standard motor speeds of 710, 860, 1,160 and 1,430 r.p.m. are accommodated.

■

"E. C. & M." Type NT Master Switch

INTENDED for use on cranes, hoists, and other applications where speed control from a master switch is desired, the Type NT master switch has been placed on the market by The Electric Controller & Manufacturing Company, 2700 E. 79th St., Cleveland, Ohio. Refinements to insure smooth and easy operation include: the use of ball bearings; short throw of the operating handle; absence of gears, and the fact that the contact fingers always ride on uninterrupted plane surfaces.

The width of this master switch has been kept as small as possible in order that several of them can be mounted in a crane cage or operator's pulpit. The switch can be mounted in an upright or inverted position. As shown, it is entirely inclosed by heavy gage steel cover and is arranged for conduit connections. The Type NT master switch is built to give a maximum of six points of speed control in each direction, with overload reset at the "off" position.

"E. C. & M." Type NT Master Switch

■

"O-Z Anemo" Tachometer

INTENDED for use in research laboratories for the measurement of the air velocities of fans, blowers, and exhausters, the "O-Z Anemo" Tachometer has been placed on the market by the O. Zernickow Company, 15 Park Row, New York, N. Y. This instrument is a combination of a Robinson cup cross and a centrifugal tachometer. The cup cross is located on the extension of the pendulum shaft, and when exposed to an air current, it receives a very definite angular velocity in such a manner that the average absolute speed of the cup center is in approximately a constant relation with the wind velocity.

"O-Z Anemo" Tachometer for measuring the air velocity of fans, pumps, compressors, and other equipment

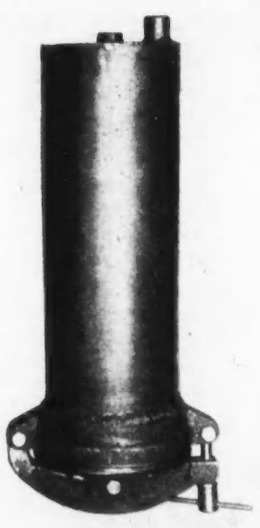
The plain dial has double graduation, from 10 to 70 miles per hour and 5 to 35 meters per second. Other ranges and graduations can be made to order. The over-all length without the handle is 8½ in., and with handle for use as portable instrument, it is 12¼ in. The dial is 4 in. in diameter.

■

Nugent High-Pressure Automatic Bypass Oil Filter

HIGH PRESSURES are withstood successfully by the automatic bypass filter announced by the Wm. W. Nugent & Company, Inc., Chicago, Ill. The filter is suitable for application to Diesel engines, oil-engine electric locomotives, airplanes, hoists, dredges, trucks, tractors, rolling mills, large bearings, and other equipment. It is not affected by jars, vibration, switching, pitching nor rolling.

Automatic bypassing of the correct amount of oil to an engine or machine in case the mechanic has neglected to clean it, is a feature of this filter. A working pressure of 100 lb. per sq.in. can be withstood by the device, which has an inlet through the bottom and an outlet from any point about the filter. It may also be placed in the pump discharge or suction line. In addition, it may be set vertically or at an angle.



Nugent High-Pressure Automatic Bypass Oil Filter

As for the interior construction, the open ends of four filtering bags are securely fastened to four projecting oil nozzles on a central distributing spool. The filtering elements are rolled up about this distributing spool with a wire spacing mat between each. These spacing mats permit the

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oil to reach every square inch of surface, thus obtaining a large amount of filtering area in a small space. Any desired degree of filtration may be obtained by adding the desired number of filters. The filtering element is made in different grades to filter oils of different viscosities.

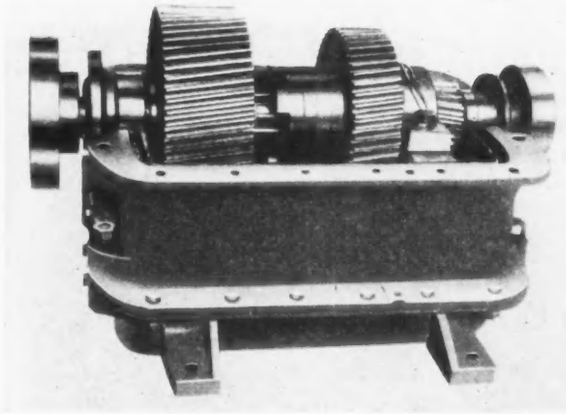
■

Westinghouse-Nuttall Two-Speed Gear Unit for Stoker Drives

FOUR STOKERS can be driven by a single Westinghouse-Nuttall, 12-hp., two-speed stoker drive unit illustrated below. This drive has been placed on the market by the Westinghouse Electric & Manufacturing Company, Pittsburgh, Pa. Provision for operation at two different speeds is a feature. A ratio of 5.88 to 1 is obtained at the high speed and 12 to 1 at the low speed. A 12-hp., 600-900 r.p.m. motor is required for slow speed service and a 1,200-1,800 r.p.m. motor for high speed operation.

In a three-section case, the high-speed pinion shaft and a splined shaft, on which the change gear arrangement is assembled, are aligned directly above the shaft on which is the intermediate gear and two slow-speed pinions. These two slow-speed pinions have different numbers of teeth and are cut integral with the shaft. A cross-member inside the case carries one end of the high-speed shaft and one end of the low-speed splined shaft, the other ends of these shafts being supported by the ends of the case. The two gears of different size on the low-speed shaft are mounted on roller bearings. Between these two gears is a sliding clutch manipulated by a lever from the outside of the case. Moving the clutch toward one end or the other of the shaft engages either of the gears, depending upon whether the high or low speed is desired.

Timken bearings are used throughout, except for the floating gears. Helical gears are used exclusively and are made from forged steel and heat-treated. Gears and bearings are lubricated by a positive splash system, the intermediate gear and a disk at the opposite end of the lower shaft carrying the oil from the reservoir in the bottom section of the case.



View of the interior of a Westinghouse-Nuttall Two-Speed, Double-Reduction Gear Unit for Stoker Drives. One unit is capable of driving four stokers

■

Westinghouse Photo-Electric Cell and Amplifier Unit

A PHOTO-ELECTRIC cell with an anplifier is now sold as a unit by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. The photo-electric cell, often called the "electric eye," is a light-sensitive device. When light falls upon it after voltage has been applied to the cathode, a current passes by means of an electron emission from the cathode to the anode. This current is very small, but when amplified, it operates commercial relays.

The amplifier unit shown in the illustration consists of a die-cast aluminum box, in which are mounted the necessary coupling devices. The top, which is a Micarta panel, is provided with two four-prong bases for mounting the photo-electric cell and the amplifier tube. All of the wiring is concealed, connections being made to binding posts on the top panel. The unit is dustproof and moisture-proof. The short connections in the unit make possible a very high speed response of between 0.0001 and 0.001 second.

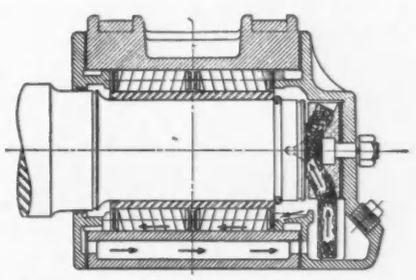
The photo-electric cell is applicable to tasks now requiring tiresome watching by the human operator. Some of the many applications are: sorting materials, according to color, size and shape; counting items where mass production requires speed; scanning material to detect flaws or defects, and the controlling of an alarm system.

Westinghouse Photo-Electric Cell and Amplifier Unit

■

Fafnir-Melcher Railway Journal Bearing

A SPECIAL ALLOY outer race made integral with the housing is the chief feature of the Fafnir-Melcher railway journal bearing announced by the Fafnir Bearing Company, New Britain, Conn. It is claimed that the use of this special alloy results in less wear at the pedestal and equalizer seats. A sleeve comprising the inner race, a roller assembly, and an outer housing, in which the roller path is integral, are the three main parts. The rollers take only the radial load, all lateral thrust being absorbed by the bronze thrust bearings.



Fafnir-Melcher Railway Journal Bearing with integral outer roller path

The housing itself is composed of three parts: the front cover, which houses the thrust bearing and lubri-

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cating wick; the rear cover containing the oil seal grooves and dust guard, and the center member, in which are embodied the roller equalizer seat, the pedestal flanges, and an oil reservoir. An advantage of this construction is the greater wall thickness permitted, which, of course, increases the strength of the box.

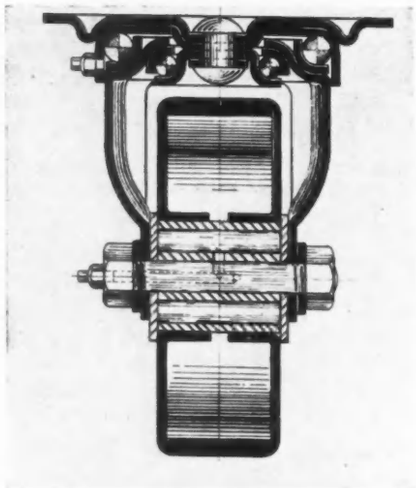
The roller assembly consists of two sets of flexible rollers, each contained in a spacer bar cage. A constant circulation of lubricant at a flow of 15 to 30 drops of clean filtered oil per minute through the bearing permits operation of a car so equipped for 100,000 miles without inspection or attention. The oil in the reservoir is circulated every 300 miles.

To reduce shock and train noises, this bearing is provided with a non-metallic pad in the housing and between the point of impact and the load, so as to break up constant metal-to-metal contact. This pad is molded from ground cork mixed with a special binder. Through its use the bearing life is increased, and the riding qualities are improved.

■

Saginaw Parkerized Ball-Bearing Casters

IN ORDER to combat corrosion and thus maintain maximum operating efficiency, the roller bearing casters manufactured by the Saginaw Stamping & Tool Company, Saginaw, Mich., are now Parkerized. A cross-sectional view of this caster is given, showing the ball-bearing construction.



Cross-sectional view of the Saginaw Ball-Bearing, Pressed-Steel Caster

It will be noted that the corners of the wheel are well rounded to eliminate floor cutting, and that the stock from which it is made is particularly heavy to maintain its shape under the maximum loads for which it is offered. Casters are available in a range of sizes.

■

Cutler-Hammer Overload Switch for Small Motors

A FREE-TRIPPING thermal overload switch for small motors has been announced by Cutler-Hammer, Inc., 2-12th St., Milwaukee, Wis. It is

Cutler-Hammer Overload Switch for fractional-horsepower motors

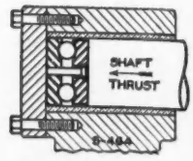
known as the Bulletin 9101. According to the manufacturer, the switch provides positive protection against motor burnouts due to overloads, prevents blown fuses and other electrical troubles caused by overloads. Push buttons furnish convenient starting and stopping control. The switch has a time-limit type of thermal overload, which is furnished in numerous ratings up to and including $\frac{3}{4}$-hp., 110- and 220-volt a.c., and $\frac{1}{4}$-hp., 115-volt d.c. When an overload trips the switch, it is re-set by simply pressing the start button; this also restarts the motor. If the overload condition persists, the motor will not start.

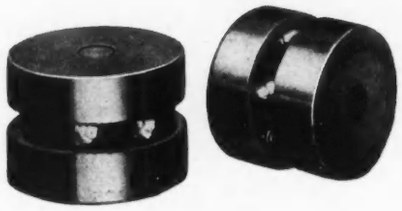
■

Auburn T-114-RG End-Thrust Ball Bearing

THE END thrust bearing T-114-Rg illustrated has been placed on the market by the Auburn Ball Bearing

Obtainable in standard shaft diameters, this bearing simplifies assembly





Auburn T-1J4-RG End-Thrust Ball Bearing

Company, Rochester, N. Y. This bearing fits in a recess at the end of the shaft, the recess being of the same diameter as the shaft, so that a minimum of machine work is required. Because of the small pitch diameter of the ball groove for a given shaft diameter, and because of the large size balls used, the peripheral speed of the balls is relatively low.

The two races and balls are held together as a unit by a rod in the center, which is flanged on the ends, permitting free rotation of the races, yet holding them together. This is also a convenience in handling and installing the bearing. The races are heavy in section.

The bearings are available in sizes from $1\frac{3}{16}$ to $3\frac{15}{16}$ in. in diameter.

■

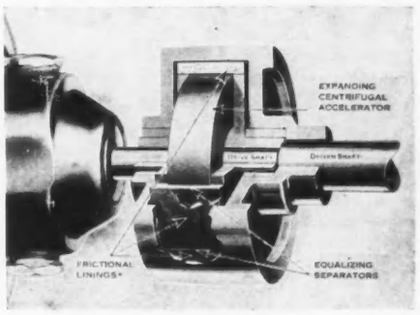
Lombard Automatic Starter or Clutch

CENTRIFUGAL force expanding a rotating flexible, fluid container against suitable friction surfaces is the principle employed in the Lombard automatic starter or clutch announced by the Washburn Shops of the Worcester Polytechnic Institute, Worcester, Mass. This centrifugal force is exerted by a fluid sealed within the rotating container, and the interval of time required for the fluid to distribute itself uniformly around the inside is the time allowed for bringing the driven machine up to speed. The gradual building up of the centrifugal force results in smooth pickup.

The accelerator is wholly inclosed, and is protected by the frictional lining. Among the advantages are: greatly reduced peak load require-

NEW MATERIALS AND PARTS

ments for driving units; practically any desired starting condition may be obtained for the driven shaft; shock is absorbed and wear and tear reduced on the driving and driven units; standard motors and in many cases smaller motors may be used; minimum power is required, and the power factor is improved. The device is manufactured for direct connection or for gear, chain, V-belt or flat-belt drives in any size desired. It will operate in either the horizontal or the vertical position, or in either direction of rotation. The fluid employed is usually mercury for the smaller sizes, and water for the larger sizes. There can be no leakage of the fluid, as the accelerator is permanently sealed.



Lombard Automatic Starter or Clutch

REVIEW OF RECENT PATENTS

Parts and Mechanisms

The Twin Disc Clutch Co. is assignee of patent 1,724,361, covering a clutch operated by spring links and lever arms, the latter being pivoted on a hub and connected to a pair of clamping disks.

Patent 1,724,635, granted to Stanly W. Bath, of Worcester, Mass., and assigned to John Bath, relates to a table driving mechanism, operated by hydraulic means, and having an automatic arrangement for starting a motor connected to a valve gear.

Francis J. Lapointe, of Ann Arbor, Mich., has been granted patent 1,732,445 on a quick-acting broach locking device having a spring-pressed jaw on each side of the socket and members for forcing the jaws against the broach.

A mechanism comprising a pair of rotary cutters, between which is a friction ring, is the subject of patent 1,723,660, assigned to the Adriance Machine Works, Incorporated.

To the Victor Manufacturing & Gasket Co. has been assigned patent 1,748,582 on a gasket consisting of layers of sheet metal and interposed non-metallic material and each having an opening, one of said layers having a wall extending through said opening, and a sheet-metal reinforcing element between and secured to said sheet-metal layers adjacent to the edge of the opening and next to said wall, each of said layers being disposed in overlapped relation to each other and to the reinforcing element.

Materials

An alloy consisting mainly of nickel and iron in proportions of at least 2½ to 1, also containing chromium, tungsten and molybdenum in substantial amounts but not aggregating over 8 per cent, and a small amount of manganese, is the subject of patent 1,726,489, allowed to Noah V. Hybinette of New York, N. Y.

Patent 1,729,386, assigned to the Farrel-Birmingham Co., relates to an iron alloy containing more than 2.25 per cent carbon, copper from 0.25 to 2 per cent, molybdenum 0.10 to 2 per cent and chromium up to 3.5 per cent.

Manganese steel responsive to air toughening, and containing less than one per cent of carbon, an effective amount up to 5 per cent of nickel, less than 0.5 per cent of silicon, and 10 to 15 per cent of manganese, is the subject of patent 1,732,202, assigned to the Taylor-Wharton Iron & Steel Company.

PUBLICATIONS

DRAWING REPRODUCTION PROCESSES. The Charles Bruning Co., Inc., 102 Reade St., New York, has made up a booklet showing specimen drawings as reproduced by nine different processes. The booklet is entitled "Manual of Reproduction Processes."

DURALOY, A CHROME IRON. The Duraloy Co., Pittsburgh, Pa., has published bulletin No. 3012 on "Duraloy," a chrome-iron, which is suitable for applications requiring resistance to oxidation, corrosion, and abrasion. Pictures are given of various products in which the design problems have been met successfully with this material. A table of its characteristics is appended.

FLOW METERS, ELECTRIC. The Brown Instrument Co., Philadelphia, Pa., has published Catalog No. 21, illustrating the application of its electric flow meters to the measurement of steam, water, air, gas, oil, and other fluids. Eight models are shown. The catalog contains 89, 11x8½-in. pages.

GENERAL ELECTRIC PUBLICATIONS. The General Electric Co., Schenectady, N. Y., has issued several bulletins as follows: Bulletin 19F, superseding 19E and in part 181B, on Type CR-7006-D5 and -D7, a.c., inclosed magnetic switches for a.c. motors; Bulletin 904C, superseding 904B, on single-stage centrifugal air compressors for cupola blowing; Bulletin 1045A, on several Type CL-2 control and instrument switches; Bulletin 1196 on Type CN-1 air circuit breakers for 650 volts., a.c. or d.c. circuits, and Bulletin 1231 on quiet-operating induction motors of the 900 and 500 series frames.

INSTRUMENTS, OPTICAL. The Bausch & Lomb Optical Co., Rochester, N. Y., has published a booklet entitled "Precision Through Optical Methods," which illustrates and describes several new optical instruments, some of which are of use in metal working plants and the laboratories thereof. The booklet contains nineteen 9x6-in. pages.

MOTORS. The Triumph Electric Corporation, Cincinnati, Ohio, has published bulletin No. 2015 on its type "TR" self-start motor, which develops torques up to 300 per cent of its normal rating on starting. A cross-sectional view is given, performance characteristics are shown, and the machine is clearly described.

NICKEL CAST IRON. The International Nickel Co., Inc., 67 Wall St., New York, has published "Notes on Uses of Nickel Cast Iron," which lists the recommendations for the use of the material in the automotive, aeronautical, general machinery, machine tool, and power industries.

ROLLER BEARINGS, HEAVY-DUTY. The American Roller Bearing Co., Pittsburgh, Pa., has published a catalog entitled "American Roller Bearings," which shows medium-duty, heavy-duty and super heavy-duty types, and gives the range of sizes and load capacities. A wide range of equipment using these bearings is illustrated, and drawings show the various methods of installation with regard to end plate construction, doweling of the inner races and control of thrust.

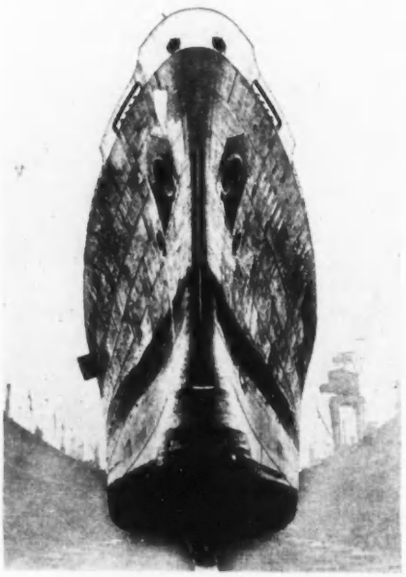
ENAMELS FOR SHEET IRON. The University of Illinois, Engineering Experiment Station, has published bulletin No. 201 entitled "Acid Resisting Cover Enamels for Sheet Iron," which gives the results of an investigation on the composition of various enamels and contains a description of the processes involved in the preparation of enamels and the details of tests made to determine the resistance to acids. Conclusions are considered separately. Copies of this bulletin may be obtained without charge.

WHAT'S GOING ON—

The Month In Product Design

MAN'S eternal craving for greater speed, increased safety, and more comfort were the influencing factors in salient design developments of March. The *Silver Bullet*, Kaye Don's English racer, here for a speed test, shows several new ideas in the control of fast automobiles, according to the S.A.E. Journal. The *Silver Bullet*, built by the Sunbeam Motor Car Company to have a speed of 245 miles per hour, has but 0.42 times the wind resistance of Seagrave's record-holding *Golden Arrow*. The twin 2,000-hp. engines are geared to their drive shaft at 30 to 13, the engine drive shaft to the wheel drive shaft at 23 to 20, and the final drive to the wheels at 12 to 33. This makes the engine-to-wheel ratio 1 to 1.04, or about 1 to 1! A 4-in. carburetor feeds the supercharger which is turned by a "nut" on a drive shaft designed to relieve inertia and mounted between the engines. An "air-resistance" brake, with a reaction of half a ton at 250 m.p.h., supplements the 4-wheel water-cooled hydraulics, and is a simple vane presenting, in braking, its flat surface to the air stream.

A TWIN-FLOAT, all-metal, passenger monoplane, which weighs more than 9 tons, is nearing completion in England, according to *Foreign Aeronautical News*. Its span is 107 ft. with a distance of more than 20 ft. between the floats. The designer is trying out, in this plane, the comparative merits of the boat hull as against the separate fuselage with floats. The rather square box-type fuselage gives a spacious cabin in which a tall man can stand upright, the flat sides allow large sliding windows, and the monocoque construction eliminates all inside struts or braces. The pilot's cabin is entirely enclosed, the roof is of safety glass with a panel which can be slid back in mooring. The operator's and navigator's compartment lies between those of the pilots and the passengers, and baggage is carried in the unusually large tail. Three Bristol Jupiter geared engines, giving a total of 1,575 hp., are fitted in cradles with anti-vibration rubber insulators. The central engine is set low in the nose, the others, with their oil tanks, are slung under the wing. Main spars of the wings are built of Duralumin sheet, the leading edge back of the front spar is Duralumin sheet and a metal walkway on top of the wing is provided with other walkways back to the ailerons hinges. Otherwise, fabric is used for covering. Gravity fuel feed supplies the 350 gallons of fuel. Cruising range is expected to be 500 miles at 136 miles per hour. Fully-laden weight is 20,685 lb., of which 7,984 lb. is available for load. There is space for 17 passengers.

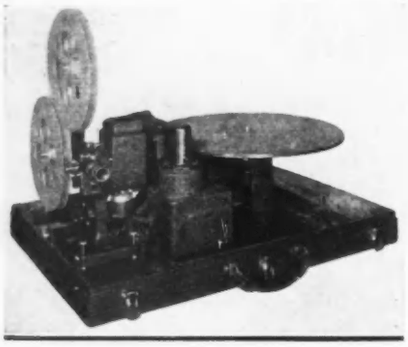


The Lloyd flyer Europa, showing the bulbous bow which creates dead water at the propellers

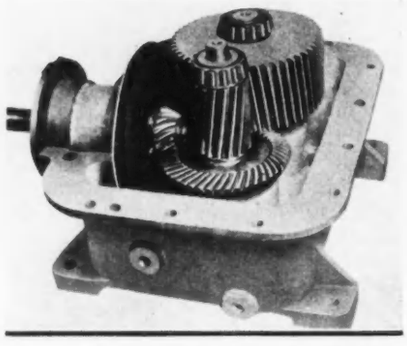
Jenkins Model 100 Radiovisor, radio vision equipment for home use, designed to operate on 110-volts

The Department of Commerce has issued an approved type certificate on the Packard Diesel aeronautical engine. Rated horsepower of the new engine is 225 at 1,900 r.p.m., and dry weight is 510 lb. giving a unit weight of 2.27 lb. per hp., as compared with an average of 2.33 for carburetor type engines. The engine is a full Diesel 9-cylinder radial, air-cooled, four-cycle type, having a $4\frac{3}{16}$-in. bore and a 6-in. stroke. It is understood that ignition by compression is used, and that the hot-ball system is not. Solid fuel is injected by individual cam-operated spring plunger pumps and nozzle units working under tremendous pressure.

Britain is now claiming credit on two new warship designs, one a destroyer, the other a cruiser. The destroyer *Acheron*, fitted with high-pressure boilers, 312 ft. long, displacing 1,330 tons, and with an estimated speed of 35 knots, is driven by geared turbines



QRS-DeVry Cinetone, new portable talking movie projector, synchronous-motor operated



Timken-bearing equipped, 10-1 double-reduction gear unit, splash lubricated and oil sealed

driving twin screws. The principal armament is eight 21-in. torpedo tubes on quadruple mounts and four 4.7-in. guns. Sir Charles Parsons, designer, claims the ship will be 10 to 15 per cent more economical than her sister ships because of her three oil-fired, superheated boilers and furnaces supplied with pre-heated air. The 8-in. gun cruiser *York* of 8,400 tons, has accommodations for two airplanes and her six long-range guns can be fired almost up to the limit of visibility, according to the *New York Times*. Planes will be catapulted from the roof of a turret. The ship is claimed to have the speed and fighting ability of the present 10,000 tonners.

THE PHOTO-ELECTRIC CELL, popularly called the "electric eye," was demonstrated by J. V. Breisky, Westinghouse research engineer, as a new and accurate method of finding steel temperatures instantaneously, reducing the chance for spoiled steel which now costs American steel mills millions of dollars each year. Dozens of other applications have been found for the electric eye, and it has become such a factor in industry that a new magazine, *Electronics*, devoted to the cell and the vacuum tube, is being started this month.

DOMESTIC APPLIANCES in wide variety have been placed on the market during the month, utilizing the newer alloys and combinations of the old and the new which means added comfort in the home and improved design by the engineer. Among them, according to *Electrical Merchandising*, is the all-metal Universal Ironer, priced at about $100, and still incorporating long wear and excellent construction. When not in use, a special porcelain cover slides over the top to convert it into a kitchen table. The feed board is also porcelain enameled. The finish is pearl gray lacquer, and the total weight is but 210 lb. The ironing shoe is chromium plated, and can exert 100 lb. of pressure on work if desired. Several little conveniences indicate the designer's attention to the needs of the housewife, among them two swinging racks for clothes, a swinging shelf and top, cut-away frame, automatic foot-pedal control, encased transmission, easy-running swiveled casters, and the familiar open-end roll.

The Edison D40 automatic coffee urn uses two Calrod units, one 1,000 watts, the other 100 watts. The body of the urn is of nickel-plated copper, as are the coffee basket, water distributor, and pump. The base casting is aluminum and the legs are non-rusting white metal composition. All wiring and switch connections are enclosed. The urn is equipped with a thermostatic safety switch, and also utilizes a throw-over switch for the operation of two urns together.

SHEET ALUMINUM is used as the oven lining in the Niagara Wall Socket stove, just produced by the Jewett Refrigerator Company. Corners of the oven are rounded, aluminum oven trays are supported by ribs pressed into the sidewall oven lining. The range has one external cooking element mounted on top of the oven section and two, an upper and a lower, within the oven.

A Glance Over the Pages—

1. *How is load deflection reduced on ball bearings? p. 162*
2. *What advantages has walnut for steering wheels? p. 167*
3. *In specifications, what does "tenderness" mean? p. 200*
4. *What engineer was awarded this year's Guggenheim research Medal? p. 197*
5. *What are the braking features of the "Silver Bullet"? p. 195*
6. *What thought should be given to the "identification marker"? p. 178*
7. *How can material in a section be distributed properly? p. 159*
8. *What can the engineer do about standards? p. 169*
9. *What are the bending moments in a circular ring? p. 185*
10. *How long should engineering records be kept? p. 182*

All three elements may be removed by loosening three stud contact screws, and are placed in insulated aluminum trays. The external heating element is 1,000 watts, the others are 500 each. The oven measures 13x13x15 in. and is insulated with 2-in. walls of mineral wool. All materials used in construction are rust-proof, and cooking top, sides, shelves, and splasher are finished in various colored porcelain enamels.

News of the Metal Markets

TIN prices, steady and quiet until April 1, broke suddenly to 36¼c., according to *Engineering & Mining Journal*, and have now succeeded in advancing only a fraction above that. Although the stock of this plating and bearing metal dropped during February and March, stocks are still considerably greater than they were a year ago, and the unlicensed warehouses are said to be stocking up on the continued high production. The price seems on the upgrade, however, prices toward the end of March, in some instances around 35¾c., having seemingly marked the low point. These prices are the lowest that tin has reached since 1922, and indicate the possibility of its regaining its former secure position in the metal-working field.

COPPER sales, although only for immediate wants, are showing improvement, while the price stays firm at 17.775c. Foreign business is moderate and there is considerable demand for wire, but stocks are still accumulating and the price may be forced down. Copper fabrication has shown some increase and domestic consumption is averaging about 80 per cent of last year's rate.

LEAD demand continues at a good rate, March's sales being up. Paint, foil, battery, and cable manufacturers are taking most of the metal, now lacking in favor since zinc is definitely underselling it. Prices are unchanged at 5.6c., and current production is taking care of the demand.

ZINC demand is also improving, after a weakness which took the price down to 4.80c. Galvanizers are showing more interest in the market, and other sales are good. Producers are decrying the opening of new mines producing zinc as a by-product, particularly because of the tendency of these mines to leave zinc production unrestricted.

SILVER is quiet and dull at about 42c. The demand for nickel to be used in alloys is increasing, and aluminum demand is also good. The use of aluminum alloys is increasing steadily.

A 57-ft. coal loader, built by Westinghouse, with all motions powered by 13 motors controlled by one operator. This machine will load a ton of coal every ten seconds

IN THE SPOTLIGHT—

MAJ.-GEN. C. C. WILLIAMS, Chief of Ordnance, U. S. Army, who is responsible for the great development metallurgical research has undergone during his supervision, retired on April 1. Quantity production and economy of manufacture resulted from the research program.

L. V. REDMAN, vice-president and director of research and development of the Bakelite Corporation, delivered a paper entitled, "Phenol Resinoids and the Automobile" before the Detroit regional meeting of the A.S.T.M. on March 19 as a part of a symposium on developments in automotive materials.

E. C. BULLARD has been appointed research and development engineer of the Bullard Company, Bridgeport, Conn. He was formerly assistant mechanical engineer, and was recently elected to the board of directors.

V. E. ANNIX, associated with the Greenfield Tap & Die Corporation, Greenfield, Mass., for about 19 years, recently as production manager, has been transferred to the engineering department in the Detroit office.

E. C. BAIN, metallurgist for the United States Steel Corporation, Kearny, N. J., will be the speaker at the April 8 meeting of the Hartford (Conn.) Chapter of the American Society for Steel Treating.

R. S. BEGG, until recently chief engineer of the Stutz Motor Car Company, Indianapolis, has been appointed chief engineer for the Midland Steel Products Company, Cleveland, in full charge of its engineering activities, including direction of the work of its new experimental laboratories.

GASTON L. P. DE BETHUNE, member of the A.S.M.E. and representative of the Federation of the Association of Belgian Engineers at the A.S.M.E. Golden Anniversary observances, was awarded the 50th Anniversary Medal for Belgium.

FRANK W. CALDWELL, chief engineer of the Standard Steel Propeller Company, delivered a paper on "The Drop-Forged Metal Propeller" at the Pittsburgh Aeronautic Conference on March 12, sponsored by the A.S.M.E. and the newly formed aeronautic section of the Engineers' Society of Western Pennsylvania.

GEORGES CLAUDE, well-known French scientist and inventor, member of a number of technical societies and possessor of many decorations for his contributions to science, is the 50th Anniversary Medallist from France, and delivered the monograph from that country at the A.S.M.E. celebration in Washington.

DEAN MORTIMER E. COOLEY, past president of the A.S.M.E. and dean of engineering at the University of Michigan, was presented the Washington award of the Western Society of Engineers at the dinner meeting of that organization and the four national engineering societies in Chicago recently.

L. C. CONRADI has been appointed metallurgist for the Lycoming Manufacturing Company, Williamsport, Pa. Previously he was chief chemist of the Plainfield (N. J.) Manufacturing Corporation, a division of the Spicer Manufacturing Corporation.

FRANK W. CURTIS, formerly chief engineer for P. R. Mallory & Company, Inc., Indianapolis, is now research engineer with the Kearney & Trecker Corporation, Milwaukee. Mr. Curtis is the author of articles and books treating with tool design and gaging methods.

C. C. Williams

L. V. Redman

E. C. Bullard

PROF. DANIEL DRESDEN, president of the Jaffa Engine Works, Utrecht, Holland, a consulting engineer of note, was the A.S.M.E. medallist from Holland at the Golden Anniversary observances.

LUDWIG ERHARD, director of the Technical Museum, Vienna, honorary member of the Technical Universary of Vienna, and president of the Austrian Society of German Engineers, delivered the monograph for Austria at the Washington session of the 50th Anniversary of the A.S.M.E.

DR. ROBERT H. FURNALL, Whitney professor of dynamic engineering and director of the mechanical engineering department of the University of Pennsylvania, has been appointed dean of the Towne scientific school of the University, according to a recent announcement by Provost Josiah H. Penniman. Mr. Furnall is a former vice-president of the A.S.M.E.

DONATO GAMINARA represented Uruguay at the A.S.M.E. 50th anniversary.

CARL EWALD GRUNSKY, consulting engineer of San Francisco, and former member of the Panama Canal Commission, delivered the monograph for the United States at the A.S.M.E. Golden Anniversary celebration.

H. H. HARRIS, president of the General Alloys Company, Boston, and a partner in Noble & Harris, Detroit, consulting engineers, returned recently from an airplane tour of Mexico, during which he made a survey of the engineering projects of the Mexican government.

CHARLES A. HAYNES, mechanical, industrial, and electrical engineer, who has practiced in this country, England, Canada, Africa, and India, and who for the past five years has been connected in executive capacities with the Truscon Steel Company, Youngstown, Ohio, has been appointed manager of the Transmission Structures Division.

E. L. Ives, vice-president of H. A. Brassert & Company, Chicago, consulting engineers, sailed recently for England on a business trip.

MASAWO KAMO, head of the department of mechanical engineering of Tokyo Imperial University, is the A.S.M.E. 50th Anniversary medallist from Japan.

LUIGI LUIGGI, senator of the Kingdom of Italy and noted engineering authority of his country, delivered the monograph for Italy at the A.S.M.E. 50th Anniversary observances.

CONRAD MATSCHOSS, director of the Verein Deutscher Ingenieure, historian of the development of the steam engine and a life member of the A.S.M.E., delivered the monograph from Germany at the 50th anniversary celebration of the Society in Washington.

VILLOR P. WILLIAMS, chief engineer of the Automotive Corporation of America, is co-operating in the formation of a Baltimore section of the Society of Automotive Engineers.

ORVILLE WRIGHT, inventor and constructor, with his brother, of the first successful engine-propelled airplane, was awarded the Guggenheim Medal for "notable achievement in the advancement of aeronautics" by WILLIAM F. DURAND, president of the Guggenheim Medal Board, at the 50th Anniversary observances of the A.S.M.E. in Washington.

JOSEPH W. ROE, professor of industrial engineering at New York University, was presented with the Melville Medal of the A.S.M.E. at the anniversary observances in Washington recently.

WILLIAM L. EMMET, consulting engineer with the General Electric Company, was awarded the A.S.M.E. medal by President Charles Piez at the Golden Anniversary observances for his contributions in the development of the steam turbine, electric propulsion of ships, and other electrical generating apparatus.

FRED J. MILLER, past president of the A.S.M.E., was awarded the Gantt Medal by LEON P. ALFORD, chairman of the Gantt Medal Board at the Anniversary observances in Washington of the A.S.M.E. The award was made for "distinguished achievement in management."

LOUGHNAN ST. L. PENDRED, president of the Institution of Mechanical Engineers, and an honorary member of a number of other engineering societies and organizations, was the recipient of the A.S.M.E. 50th Anniversary medal for Great Britain.

VILHELM F. A. NORDSTROM, technical manager of the De Laval Steam Turbine Company and Swedish delegate to the conference of the International Electro-Technical Commission in New York in 1926, represented Scandinavia at the A.S.M.E. observances in Washington.

HOMER S. TRECARTIN, general manager of the Roller Bearing Company of America, Trenton, N. J., resigned effective April 1 to join the Russian organization Sharikopodskipnekstroy, represented in this country by the Amtorg Trading Corporation, New York. This organization is arranging to build and equip in Moscow one of the largest factories in the world for the manufacture of ball and roller bearings. Mr. Trecartin's work will be in connection with the direction of the design and equipment of the new plant.

KENNETH M. RONAN, formerly chief engineer of the Stinson Aircraft Corporation, has been elected president of the Warrior Aeronautical Corporation, Alliance, Ohio, successor to the Alliance Aircraft Corporation.

HOWARD S. TAYLOR, in the mechanical engineering department of Stanford University, has been appointed chairman of the program committee for the National Western Metal Congress and Exposition which is to be held in San Francisco from Feb. 16 to 20, 1931.

Orville Wright

Joseph W. Roe

William L. Emmet

Fred J. Miller

Meetings

American Foundrymen's Association—Annual Convention, Cleveland (Ohio) Public Auditorium, May 12-17. C. E. Hoyt, 222 W. Adams St., Chicago, secretary-treasurer.

American Society of Mechanical Engineers—Semi-Annual Meeting, Hotel Cadillac, Detroit, June 9-12. Calvin Rice, 33 West 39th St., New York City, secretary.

American Society for Testing Materials—Annual Meeting, Haddon Hall, Atlantic City, N. J., June 23-27. C. L. Warwick, 1315 Spruce St., Philadelphia, Pa., secretary.

American Welding Society—Annual Meeting, Engineering Societies Bldg., New York City, April 22-25. M. M. Kelly, 33 West 39th St., New York City, secretary.

Association of Iron & Steel Electrical Engineers—Annual Convention and Exposition, Broadway Auditorium, Buffalo, N. Y., June 16-20. John F. Kelly, Empire Bldg., Pittsburgh, Pa., managing director.

International Congress for General Mechanics—Liege, Belgium, Aug 31-Sept. 7. For information address Alb. Schlag, 4 Place Saint Lumbert, Liege, Belgium.

National Power Show—In connection with International Textile Exposition, Mechanics Bldg., Boston, Mass. April 28-May 3. For information write New England Association of Commercial Engineers, 53 Devonshire St., Boston, Mass.

Society of Automotive Engineers—Summer Meeting, French Lick Springs Hotel, French Lick Springs, Ind., May 25-29. C. F. Clarkson, 29 W. 39th St., New York, N. Y., secretary.

Obituaries

JOHN O. ARNOLD, emeritus professor of metallurgy at Sheffield University, London, died on March 28. He was one of the pioneers in the production of high-speed steel, and discovered the influence of vanadium on steel. During the World War, when vanadium was difficult to obtain, he substituted molybdenum for tungsten and succeeded in producting a remarkably powerful cutting tool. He was 73 years old.

CAPT. WILLIAM A. PRATT, railroad engineer, died at his home in Waynesboro, Va., on March 16, of double pneumonia. Captain Pratt built a part of the Baltimore & Ohio Railroad, and later became development engineer for the company.

ERNST F. EURICH, 82, for more than twenty years a consulting mining and metallurgical engineer in New York, died at a hospital in Utica, New York, recently.

GEORGE F. SMITH, inventor and president of the George F. Smith Oven Company, Inc., died on March 10 at Baltimore, after an illness of more than a month. He invented and patented several devices for the improvement of the rotary baking oven.

AUGUSTUS H. BULLARD, 63, secretary and treasurer of the Bullard company, died on April 5, after an illness of a month.

Research and Engineering in the Capital

By PAUL WOOTON

Washington Correspondent, Product Engineering

OUTSTANDING in engineering gossip this month in Washington is the resignation of Maj. Gen. C. C. Williams, Chief of Ordnance, on April 1, after 39 years of service. The metallurgical research program initiated by him has produced the cold-working method of gun construction, which supersedes the former built-up and wire-wrapped methods. Stronger guns are made from one-piece forgings at a considerable saving in cost and time. The additional strength is obtained by cold-working the metal by means of hydraulic pressure applied to the bore. Investigation also has revealed that new alloy steels can be produced that are better adapted to the cold-working process and have greater resistance to fragmentation than nickel steel, of which practically all guns were made during the war.

Application of the cold-working method of gun construction has made possible the development of removable liners for high-power guns. The accuracy life of high-power guns, such as those used for anti-aircraft purposes, is low. In the past, this necessitated shipping the gun to an arsenal for retubing, but the development of the removable liner permits replacement to be made in the field in a very short space of time.

Centrifugal casting of guns also is a product of the research program directed by General Williams. Advantages of the centrifugal method are a saving in material, elimination of the forging operation and forging equipment, rapid production, and a material saving in cost per unit manufactured. So far these developments in gun construction have been confined to guns of small and medium caliber that have proved fully dependable in proving ground tests but their application to guns of large caliber also is contemplated.

Examination of metals by means of the X-ray to determine the existence of internal flaws or defects was pioneered by the Ordnance Department. Process control in the foundry and in the welding shop has been greatly aided by the use of the X-ray. Standardization of impact methods for testing steels has led to obtaining better steels for guns. Minimum impact properties now are specified for gun steels in a similar manner to tensile properties. High-power photomicrography is proving of great value in the Ordnance Department's metallurgical research. Photomicrographs have been taken for many years at from 100 to 1,000 magnification but the equipment now installed at the Watertown Arsenal produces magnifications as high as 5,000.

INTEREST in developing new uses for silver has been revived by the acute depression that the industry now is suffering. Government scientists and economists express the hope that widespread comment will crystallize in definite efforts to establish a secondary market for silver. An inclination is evident to place more emphasis upon the development and exploitation of alloys than upon extending the uses of the pure metal.

Obviously, silver alloy could not compete on a price basis with silver plated, chromium plated, and stainless steel articles, but it is equally certain that silver alloyed products would have a definite appeal. Such products would have the "luxury feel" without exacting the premium which sterling silver demands. Even a market relatively small as compared to that for chromium-plated and stainless steels would consume a tremendous quantity of silver.

THE American Engineering Council has announced the appointment of a Committee to co-operate in the publication of a new edition of "Who's Who in Engineering." The function of the Committee, according to Lawrence W. Wallace, executive secretary of the Council, is "to provide such advice on the qualifications of engineers as will enable the publishers to issue a work which shall be authoritative."

A.S.T.M. Committees Meet During Detroit Meeting

THE annual Spring Group Meeting of committees of the A.S.T.M. was held at the Book-Cadillac Hotel in Detroit, March 17 to 21. The plan of holding a number of committee meetings over consecutive days, unique in the activities of the Society, worked out successfully, conserving the time of those members serving on a number of committees. The committees met throughout all the five days, starting with sessions in the morning and extending through the afternoon and evening with but one break, a dinner on Wednesday evening.

In all 23 committees of the Society took part, but with the many sub-committee meetings that were necessary, the number of meetings held during the five days totalled approximately 125. About 500 were in attendance.

The Group Meeting was held in conjunction with the Detroit Regional Meeting, a meeting arranged by the Detroit District Committee comprising two technical sessions at which a number of papers were presented covering materials of interest to the automotive industries and a dinner in the evening. The Regional Meeting contributed largely to the high attendance and gave to the meetings an atmosphere of a general meeting of the Society. Over 700 were present at the dinner.

The meeting of A.S.T.M. Sub-Committee IV, on White Metals—Tin, Lead, and Zinc, of Committee B-2 on Non-Ferrous Metals and Alloys, was held Tuesday, March 18, in conjunction with the Spring Group Committee Meeting of the American Society for Testing Materials, in Detroit at the Book-Cadillac Hotel. It was reported that at the request of the War Department, wear and other tests of some of the alloys listed in the A.S.T.M. specifications for bearing metals were under way at the United States Bureau of Standards.

The future work at the Bureau was discussed and suggestions were made to include a study of the oil absorption properties of the surfaces of the various alloys. It was also suggested that a study be made of the effect of steel backing metal *versus* bronze backing metal in service on War Department trucks.

A suggestion was made to take up a study of type metals and also terne metal for coatings, and the committee will investigate what demand exists for specifications for these materials.

Aircraft Engineers To Discuss Problems

Two important conferences of aircraft engineers will be held in May to discuss the economic problems confronting the air transport industry, according to a recent announcement by the A.S.M.E. The first conference to discuss progressive designs for cheaper maintenance and operation will be held in connection with the New York Airplane Show, to be held at Madison Square Garden on May 3. The second conference, for outlining plans for cheaper construction methods, will form part of the fourth annual technical aeronautical meeting to be held at Wright Field, Dayton, Ohio, on May 20. Although the second meeting sounds as though it were principally of the production type, a number of the engineering details essential in designing for mass production will be subjects on which leading engineers and manufacturers will talk.

APPROXIMATELY 75,000 sq.ft. of floor space will be given to the National Metal Exposition to be held in Chicago, Sept. 22-26 by the A.S.S.T.

Definitions of Terms Used in Specifications

ENGINEERING SPECIFICATIONS require the use of a vast number of terms to explain the desired characteristics of materials specified. While many of these terms have attained a commonly accepted meaning, many others are interpreted differently by different authorities and in different localities. Specifications must, therefore, contain an explanation of any doubtful term. This in itself is not so great a difficulty, but often the meaning of terms is disputed long after specifications have been written, each party claiming that his definition of a term is the generally accepted one. It is with this difficulty in mind that the accompanying list was compiled. We hope that designers and engineers will discuss critically these suggested definitions for common terms. The terms relate only to physical characteristics, and are from many sources.

AXIAL FORCE. A force acting along the geometric axis of a bar.

AXIAL STRESS. A stress acting along the axis.

BAR. A solid of prismatic form, having the same cross-section throughout its length. *Cross-section* may be defined as the intersection of a plane normal to the axis of a bar with the bar. The *section area* is the area of this intersection.

BLISTER. A convex, hollow prominence formed by separation and raising of a film in burning.

BRITTLENESS. Relative inability to resist impact or deformation without fracture.

COEFFICIENT OF TEMPERATURE. The relative change in dimensions of a material per degree.

CRACK. A fissure or open seam, not necessarily extending through the body of a material. A *hair crack* is an irregularly running, fine, narrow, surface crevice or fissure which does not penetrate deeply.

DEFORMATION. The change in dimensions of a body caused by stress. Also called *strain.*

DETRUSION. A lateral deformation in which particles of a body apparently slip past each other. It is caused by a shearing force.

DUCTILITY. The ability of a material to undergo considerable extension at a relatively large stress beyond the elastic limit without any great increase in applied load.

DURABILITY. Resistance to disintegration or deterioration.

EFFICIENCY. The ratio of actual strength of a material to the strength of a standard. The term is often applied to riveted joints in comparing their strength with that of the solid plate.

ELASTIC FAILURE. Permanent distortion of a body or piece under load.

ELASTICITY. That property of a material which permits the strain resulting from an applied stress to disappear entirely upon removal of the applied stress.

ELASTIC LIMIT. The greatest stress per unit of original cross-section to which a material can be subjected, without the material, upon removal of the stress, showing any permanent deformation whatsoever. The proper term is *proportional elastic limit,* meaning the maximum unit stress up to which the deformation is proportional to the stress.

ELASTIC RESILIENCE. The energy recovered or work done by an elastic body when a deforming stress is released at the elastic limit.

ELASTIC STRENGTH. The limiting stress of a material above which the material will suffer appreciable permanent distortion.

ELONGATION. The increase in length of a bar or section under test expressed as a percentage difference between the original length and the length at the moment of rupture.

ENDURANCE LIMIT. The greatest unit stress in a material that can be repeated an indefinitely large number of times without causing the material to rupture. Also called *fatigue strength.*

FACTOR OF SAFETY. The ratio of the ultimate strength of a material to its working stress.

FLEXURE, OR SINGLE FLEXURE. The bending of a section caused by pure force couples unaccompanied by any shearing force.

FLOW OR "CREEP." The gradual continuous distortion of a part under continued load, usually at high temperatures.

FORCE COUPLE. A pair of opposed forces acting about a central axis.

FRACTURE. Rupture of a piece by a break through its entire thickness.

HARDNESS. Intensity of molecular cohesion as measured by the resistance to penetration by a standard tool.

LAMINATION. The division of a material into thin layers or sheets.

MAXIMUM LOAD. The greatest load a piece will hold.

MAXIMUM UNIT STRESS. Same as ultimate strength.

MODULUS OF ELASTICITY. The numerical value of the constant ratio of the stress per unit of *original*

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Definitions of Terms Used in Specifications

cross-section to the accompanying unit strain, within the proportional limit of the material.

MODULUS OF ELASTIC RESILIENCE. The energy given up per unit of volume when the stress on a material is released.

MODULUS OF RIGIDITY. Also called *shearing modulus of elasticity* and *modulus of transverse elasticity*. The ratio of the unit stress developed in a section under test to the unit detrusion.

NEUTRAL AXIS. The intersection of the neutral surface of a section or beam with the cross-section of the section or beam.

NEUTRAL SURFACE. Applied to beams and sections. That part of a beam or section under a transverse load which remains unchanged in length by the load.

PERMANENT SET. The difference or change in length of a bar or section after a stress exceeding the yield point has been exceeded.

POROSITY. The ratio of the volume of the interstices of a material to the volume of its mass.

PROOF STRESS. The maximum unit stress that may be applied for a specified short time, which will not produce a permanent deformation of more than a specified amount.

PROPORTIONAL LIMIT. The load per unit of original cross-section at which the deformation ceases to be directly proportional to the load.

REDUCTION OF AREA. The percentage difference between the area of a bar before being subjected to stress and the area of the bar after rupture. The latter will be determined by measurements taken at the point of rupture.

RELATIVE ELONGATION. The increase in length of a bar under stress divided by the original length. The *percentage of elongation* is gained by multiplying this figure by 100.

RESILIENCE. The property of a material that enables it to give up or release energy (that is, to do work) as the stress is released.

RUPTURE LOAD. The load at which a piece fractures or breaks.

RUPTURE STRENGTH. The value obtained by dividing the rupture load of a material under test by the original cross-section area.

SERVICEABILITY. The ability to render satisfactory service readily and effectively.

SHORTENING. The decrease in length of a bar or section under test, expressed as a percentage difference, between the original and final lengths.

SHRINKAGE. The diminution in dimensions and mass of a material.

STIFFNESS. The material property which is measured by the rate at which the stress in a material increases with the strain.

STRAIN. The unit extension or deformation of a body resulting from the application of a load. Thus the total extension of the piece divided by the length over which the extension is measured gives the strain. The term is usually considered to mean the principal deformation—that occurring in the direction of the load.

STRENGTH. The ability to resist physical forces imposed during handling or use.

STRESS. The force exerted upon one body by another, or by one part of a body on the adjacent or adjoining parts. The latter is commonly called *internal stress*.

TENDERNESS. The relative resistance of a material to failure induced by localized stress at some weakened point, such as sharp corners and shoulders, notches, screw threads, and similar points.

TENSILE STRENGTH. The maximum tensile load per square unit of original cross-section that a material is able to withstand.

TOUGHNESS. The relative degree of resistance to impact without fracture; the property of a material which enables it to absorb energy while being stressed above its elastic limit.

ULTIMATE ELONGATION. The ratio of the increase in length of a bar or section ruptured under tension to its original length.

ULTIMATE STRENGTH. That stress, calculated on the maximum value of the force and the original area of cross-section, which causes fracture of the material.

UNIT DEFORMATION. The deformation of a body in a unit length. Also called *unit strain*.

UNIT DETRUSION. Obtained by dividing total detrusion by the length over which it occurs.

UNIT ELASTIC RESILIENCE. The elastic resilience of a body per unit length.

UNIT STRENGTH. The maximum load which a material will support per unit of cross-sectional area.

UNIT STRESS. The force or stress upon a unit section, obtained by dividing the total axial load by the cross-sectional area.

YIELD POINT. The load per unit of original cross-section at which a marked increase in the deformation of the specimen occurs without an increase in load.

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